IRON AND STEEL ENGINEER

J. F. KELLY, Editor

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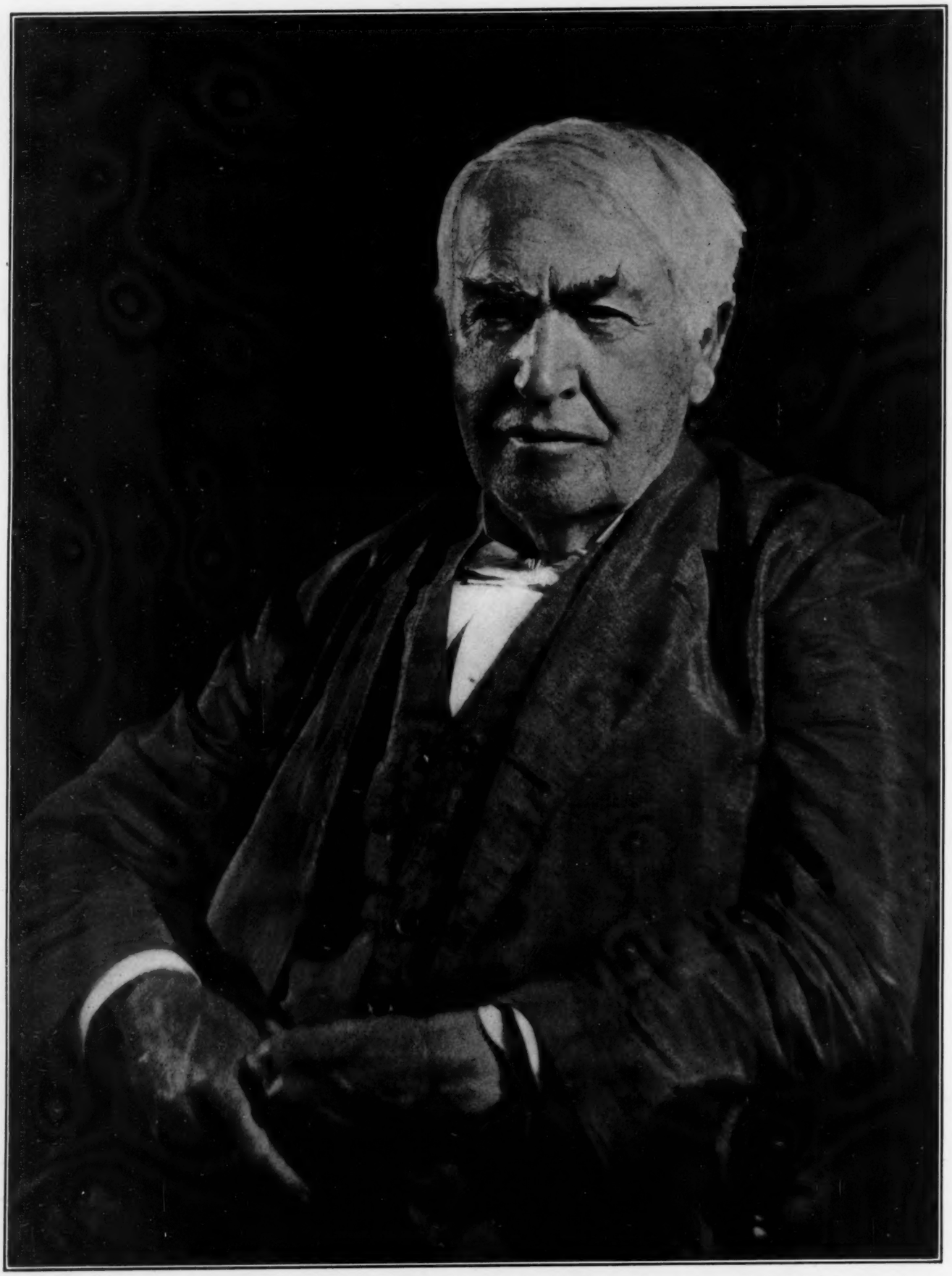

Thomas A. Edison, Engineer, Inventor, Scientist and Philosopher, who has just celebrated his 80th birthday, started at the bottom, (wound armatures with Charles P. Steinmetz) and rose rapidly from one station in life to another and today is perhaps the greatest living genius in America. Concentration, patience, common sense, are some of Mr. Edison's virtues. The AI&SEE, through the Iron and Steel Engineer, joins with the peoples of the United States in extending their sincerest wishes to Mr. Edison, one of the world's greatest benefactors.

EDITORIAL

Not so long ago, the Iron and Steel Engineer printed an editorial by an electrical engineer from one of the large steel companies entitled "The Salesman, a Consulting Specialist."

This editorial created an unusual amount of comment throughout the commercial world in this country.

We are now offering an editorial contribution from a Sales Manager of a large concern who provides a line of thought not new, but nevertheless interesting.

The Iron and Steel Engineer will be glad to print the answer to this problem, if you have one.

"We Are Standardized On—"

OH, what a bugbear these words are getting to be! Picture, if you will, yourself as a salesman, representing any real, progressive, manufacturing organization. A good factory in back of you, well equipped with machines and mechanics. An engineering force that combines inventive and mechanical ability in the highest degree.

Continuing the picture, you have been given the job of selling the product of the above described outfit. You have had sufficient technical training and subsequent commercial and practical experience to know that the product you are selling is right! Fact is you have sold some and those to whom you have sold tell you sincerely it's the best thing they have ever seen.

In other words you have sold yourself on the idea—you know you are offering the man something for his benefit as well as the benefit you would derive from the sale.

Now then—you have been out all day—early start—several calls—lot of men "not in"—others "too busy," etc., but at last you come to a plant, send your name in and the man will see you. Plant is good size. You say to yourself while waiting "this is a good prospect for our stuff."

The man comes out to see you or, better yet, he sends word out for you to come in Your hopes go a step higher and when you both finally get together you proceed with your story. At a certain flicker of interest on the man's part you concentrate on one particular piece of apparatus. It happens to be your favorite—the one you just bubble over in telling about.

Then!—oh, yes, then!—After all your enthusiastic description—your man—your customer to be (you hope) spills out the words:

"WE ARE STANDARDIZED ON —"

Oh, Boy! What wouldn't you like to say to him?

Don't you feel like saying: "My friend, it is not many years ago, as time goes, that thousands of homes—yes, even including your boyhood home and mine were

STANDARDIZED

on kerosene oil lamps for all lighting. Are you using them today? If not, why not?"

"Is your Mill—this very Mill you have charge of now—is it operating with the little old steam engines that were put in when the Mill was first built? No! Why not?"

"Are you wearing the old

STANDARD

red flannel—two-piece—half-inch thick underwear, such as you wore to the little red brick school-house that you walked two miles to get to?

No, I'll bet you are not, and furthermore, the little red brick school isn't much of a standard now and your boy doesn't walk—he drives a snappy roadster to school—eh, wot!"

Yes, you feel like saying all that to this STANDARDIZED man and, after all, who can blame you?

This time worn expression is a bad thing for the salesman, but just stop a minute and think how much worse a thing it is, unconsciously, to the man who lives and works by such a formula. As a matter of fact it can't be done and still show progress.

The only real reason in the whole wide world that any one can be justified in being standardized on a class of apparatus is when that apparatus is the best that he knows of.

The very minute his attention is called to something better—something that shows possibilities of decreasing his costs, maintenance, labor—or whatever items are affected, then is the time to begin to forget his old standard.

Of course—the man we are discussing, the standardized man, may not feel that the new article has the merit claimed for it. Naturally he has a right to use his judgment and if in such case he doesn't agree that the proposed new article is better than the present standard the question then resolves itself into a waiting game—waiting till the other fellows—the pioneers—who have tried the new device prove the merit or demerit of the apparatus. However, this man should have enough interest in his work to find out what results the pioneers are getting. To either confirm or refute his judgment.

But, getting back to the

"WE ARE STANDARDIZED —"

question. In many, many cases this standardized man uses the "spare part" argument. He doesn't want to carry so many different spare parts in stock. If the new device is as much of an improvement over his present standard as it should be to warrant recognition, then the "spare part" argument falls flat because in most cases the new apparatus, if adopted, will ultimately show a saving in cold hard cash greatly overbalancing the additional cost incurred through an additional line of spare parts.

One of the greatest corporations in the world is spending millions of dollars on a trial installation of a brand new process for producing metallic iron from the ore. Why?

Because of the probable saving in COSTS of Production. This Corporation is at present standardized on the Blast Furnace process, but evidently they do not intend to allow that fact prevent them looking for some better way as a time or money or labor saving feature.

MORAL:
DON'T STAY STANDARDIZED
TOO LONG!

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Topical Discussion—Recent Developments in Ball and Roller Bearing Applications

F. H. Buhlmann*: It is very gratifying to me, as the representative of the Rollway Bearing Company, to discuss with you the application of roller bearings to heavy duty mill motors. A meeting of this kind would have been impossible ten or twenty years ago, due to prejudice, distrust of innovations and skeptic attitude toward anti-friction bearings; and its taking place today, to discuss and adopt anti-friction bearings as a standard, is sufficient proof of how important anti-friction bearings have become to all industries in simplifying design, operation and maintenance of machinery.

It is unnecessary for me to dwell on the difficulties experienced in the operation of the sleeve bearing in mill motors, as you are no doubt more familiar with these than I.

It was this trouble, however, which gave the impulse that was responsible for the first trials of anti-friction bearings for heavy duty service which finally overcame prejudice against their use. These first tests—not considering previous unsuccessful attempts to apply automobile type bearings to motor service—were made with "Rollway" bearings and housings, the necessary changes for mounting, etc., being made by our engineers.

The first application, installed in 1910 and still in operation, was made in a G. E. type K, 30 H.P. motor driving a large drying drum used for drying soda at the Solvay Process Company's plant at Solvay, N. Y., and in this particular installation there are high temperatures to contend with, soda ash which is practically an abrasive, and considerable free ammonia in the atmosphere, so that conditions were very much against the successful operation of the bearing. This installation is still in service after sixteen years' operation, most of this time operating day and night.

Our first entrance into the steel mill field was in 1918 in a Crocker-Wheeler type W motor in crane service. This installation was made by Mr. Lawrence Hess, then Electrical Superintendent of the Youngstown Sheet & Tube Company, in conjunction with Mr. Al. Place, the Company's Electrical Engineer. The success of this installation led to Mr. Place's authorizing several other applications, all of which we understand are still in service.

About the same time, Mr. Petty of Bethlehem Steel Company began experimenting, making several installations in Crocker-Wheeler motors. The success both companies had with these applications soon became a matter of public record and led to an open discussion of the subject by the Iron & Steel Electrical Engineers.

A little later, in the year 1921 I believe, a very valuable contribution to the subject was given by Mr. McCutcheon in the form of a paper read before the Iron & Steel Electrical Engineers at their September 1921 Convention. This led to the appointment of a committee to have charge of the subject under the chairmanship of Mr. Hess, and in the following year, 1923, Mr. Petty became chairman of the committee and under the able leadership of these two gentlemen, the question of standardization of mill motors and the adoption of anti-friction bearings became a live issue.

In 1923 at the Convention in Buffalo, this special bearing committee reported on the result of a study made by them during the preceding year, which report indicated considerable progress had been made, and on January 8, 1924, a meeting was held in Cleveland at which representatives of the ball and roller bearing manufacturers were present, in addition to representatives from the electric motor manufacturers, Mr. Hipple representing the Power Club, Messrs. Petty and Hess representing the Iron & Steel Electrical Engineers, at which a complete list of general recommendations were made covering all motors from 1 to 100 H.P., which included the standard Power Club shaft extension from ¾" to 3⅜", these recommendations being, as we understand it, still officially in force, and a comparison of these sizes and the tentative sizes which we are today called to discuss brings out the fact that the armature shaft bearings in the proposed standard mill motor are somewhat larger than those recommended at Cleveland for general purpose motors of a similar rating, and considerably larger than what our Company has demonstrated over many years are necessary to use.

Why it was necessary to increase shaft diameters on sizes above G. E. MD 101, 102 and 103, or W. E. Co., M.C. 20 or M.C. 30, is not clear to us, particularly as in the years of experience we have had with bearing applications on these present-day motors, bearings of considerably smaller size than those proposed have been used by us without any difficulty. My reason for bringing up this point is based solely on the economic side of the question, as adding unnecessarily to the first cost of the motor.

On the axle recommendations, as our good friend, the editor of the Iron & Steel Engineer, has seen fit to give our friends and competitors some free advertising, I hope to be pardoned if I seem to take exception to the recommendations made. In the first place, knowing through actual experience the carrying capacity of our own bearings, we take decided exception to the implication that only one particular type of bearing has the necessary capacity to be used in the preferred series in this location—an implication entirely erroneous in the case of the product I am responsible for and I feel certain I speak for a number of my confreres in the other companies.

My Company's reason for not countenancing the use of the 200 series has not been based on the question of capacity, but solely on the fact that service as severe as mill motors are subjected to demand heavier sections than are present in the 200 series of bearings, and in making this statement, I think most of you who are familiar with our product will admit it compares favorably in strength of section with that of any other manufacturer. I

*Engineer, Rollway Bearing Co., Syracuse, N. Y.

have also been informed that exception was taken to these recommendations by a number of the A.I.& S.E.E. at the Chicago meeting and our own representative went on record to the same effect. The Chairman, Mr. A. C. Cummins, however, stated the recommenadtions had to be made up hastily and he had not had opportunity to have them passed on generally by the bearing manufacturers, and if agreeable to the Chairman, I believe that the question should be settled at this time if possible and also the question of interchangeability on sizes above 222, 322 and 420, which are the largest sizes covered by S.A.E. standards, although there are recommendations given for larger sizes. These, however, are unofficial.

Before discussing bearing applications for G.P. motors, I would like to point out for your information the reasons why our Company uses high grade carbon steel in our bearing. While with relatively low unit loads the use of low carbon steel case hardened might be permissible, yet there is another factor that has to be taken into account; namely, the useful life of the bearing, and as the severe loads and overloads often encountered in the industrial field have a habit of finding weak spots in equipment or bearings, we have adopted the use of alloy steel hardened throughout, providing the greatest possible degree of safety against abrasion of the races which might be brought about through thinness of case or excessive stresses on metal not suited to withstand the strains encountered in this class of work. To make this point clear, I have brought with me two samples, one showing a fracture of a piece of hardened high carbon chrome alloy steel such as we use in our bearings, the silky texture of which is particularly noticeable, and it is this closeness and hardness of grain that give the wearing qualities that have been the outstanding feature in our product over the past sixteen years. The other sample is that of a flat thrust plate which was actually in severe service about one year and eight months and will give a very good idea of how the rollers after wearing through the case, plowed their way into the metal, a chrome steel bearing in a more severe application showing no signs of wear whatever. This hardening throughout we have found by actual experience is particularly necessary in larger sized bearings where warping has continually to be contended with and where the chance of grinding away the case, however deep, is ever present, variations of 50 to 60 thousandths being common.

With your permission, I will now dwell for a few minutes with the comparison of ball and roller bearings and the factors to be considered in their selection for motor service.

The load capacity of ball or roller bearings is determined by the allowable pressure acting on the area formed by the ball or rollers and races, and of course depends also upon the area itself. The allowable pressure referred to depends upon the physical qualities of the material used for rollers and races and has been determined by various authorities. The contact area between rollers and races is obviously much larger than between balls and races, the roller touching along its entire length, while the ball touches theoretically at a point only. It follows that for bearings of similar size the capacity of the roller bearing is considerably larger than the capacity of the corresponding ball bearing, i. e., approximately three times for a bearing with roller length equal to roller diameter. In addition, while it is usually accepted that one-fifth of the total number of the balls of a ball bearing are under load, it can be shown that this ratio is increased to one-fourth for roller bearings. In addition, the number of rollers in our bearing is the maximum possible for the bearing size, (there being no separator.) In other words, for two bearings of the same size, being equally loaded, the unit load or strain on rollers and races is much less in a roller bearing than for ball bearings. This gives you the reason why our bearings can take additional punishment like shock load, etc., without effect, and why when for the first time applied to a mill type motor on the bridge motion of a crane of a Bessemer plant, in a location which is considered one of the worst for electrical equipment, it met at once with success.

The relatively low unit load, together with the larger area, would in many cases make the use of ordinary steel permissible, however, the races and rollers of our bearings are made of the same high grade carbon steel hardened and ground according to S. A. E. specifications, as is used for ball bearings.

The capacity of ball and roller bearings being considerably different, there arises some difficulty to adopt both types of bearings as interchangeable standards, since a given load and speed condition would naturally call for smaller roller bearings. In other words, this means that if certain bearing sizes are adopted for certain definite motors, the roller bearings would not be loaded up to their capacity, consequently they would be subject to less normal strain, their factor of safety would be much larger, their life longer and they could be subjected to considerable punishment without effect, and the expected life of 40,000 hours as given in the preliminary report of the standardization committee would be exceeded. As a matter of fact, the Rollway Bearing Company's records show bearings which have been in continuous operation for from four to nine years under the most severe service conditions like reversing blooming mills, crane motors, etc.

The loads on motor bearings, due to the various types of drives which may be used in connection with the motor are principally radial loads, i. e., normal to the shaft. It is obvious that a bearing surface normal to the direction of the applied load will be most satisfactory.

This condition is advantageously obtained with the solid cylindrical type of roller bearing with the whole roller length as active bearing surface, i. e., the contact between rollers and races being a maximum.

Now, referring briefly to the tapered roller, these bearings must necessarily be used in pairs, whether close together or at a distance apart on shafts. Their proper performance depends on set up or adjustment in mounting. It is also obvious that it is harder to manufacture this type of bearing within the accuracy of ball and cylindrical roller bearings because the two race surface cones and the rollers must have common apex on the axis of rotation. In addition, if due to adjustment or wear, this condition is changed, sliding friction would be introduced which might easily become detrimental to the bearing.

H. D. Else*: The successful application of a bearing requires not only a knowledge of the conditions of the drive but also a knowledge of the characteristics of the bearing itself. As a preface to the discussion of the application of Timken bearings in steel mill service a description of the bearing follows.

The bearing consists of a group of tapered rollers mounted between hardened steel races with a cage for spacing the rollers and holding them in place on the inner race when the outer race is removed. The active surfaces of both races and of the rollers are of conical form with a common apex in the axis of the bearing. This construction gives pure rolling motion over the entire length of the roll. The inner race of the bearing is ordinarily designated as the "cone" and the outer race as the "cup."

The principal object of the tapered construction is to provide capacity for the thrust loads incident to most applications without any great sacrifice in radical carrying power. Figure No. 1 shows a bearing with an included cup angle of a little less than 24°. Assuming a load of 100 units (AB) applied radially to the roll, the normal pressure (CB) on the roll is 102 units. The thrust capacity of this particular roll is represented by the line (AC) and is equal to 20 units. By reason of the fact that only the lower rolls in the bearing carry radial load while all the rolls are effective under thrust load, the bearing has a thrust capacity equal to its radial capacity. In other words, with an increase of 2% in the normal load on the rolls under radial loading a thrust capacity equal to the radial capacity is obtained. By varying the angle the ratio of thrust to radial capacity can be changed over wide limits.

A more or less incidental advantage of the tapered construction has proved, however, to be quite as important as the provision for thrust loading. Operation of a roller bearing, particularly at the higher speeds, requires correct alignment of the rollers with respect to the axis of the bearing. If the rollers are not accurately aligned contact with the races over their entire lengths will not be obtained and dangerous concentration of stresses on small areas will result. In figure No. 1 the reaction of the roller against the rib on the inner races is represented by the line "DE." The end of the roller makes contact with the rib on two areas "F" and "G." This double contact holds the rolls in positive alignment entirely independent of the cage and assures an equal distribution of stress over the length of the roll. The aligning principle has been checked by operating bearings without cages at the highest speeds at which the bearings are required to operate in service. The cage, however, is supplied as it acts as a retainer and reduces the relative velocity of adjacent parts.

The construction of the bearing lends itself to a variety of mountings to meet the conditions of different drives. A spaced, single bearing mounting suitable for an induction motor or similar application on which the difference in expansion of the shaft and housing is small, is illustrated in Fig. No. 2. The inner races are press fitted to the shaft to avoid creeping or peening out of the bearing seats and adjustment is accomplished by means of shims, a threaded cap, or a spring back of cup at one end of the machine. An electric motor equipped as shown will carry the thrust of helical or bevel gears and can be mounted in the vertical position with an impeller or additional weight attached to the shaft extension.

A careful study of lengthwise or axial expansion on various types of motors has been made to determine the range over which the single bearing mounting is applicable. The ordinary induction motor does not develop appreciable difference in length of shaft and spacing of enclosures under any conditions of loading. This fact is explained in part by the open construction around the shaft and in part by the fact that the heating due to iron losses is greater in the

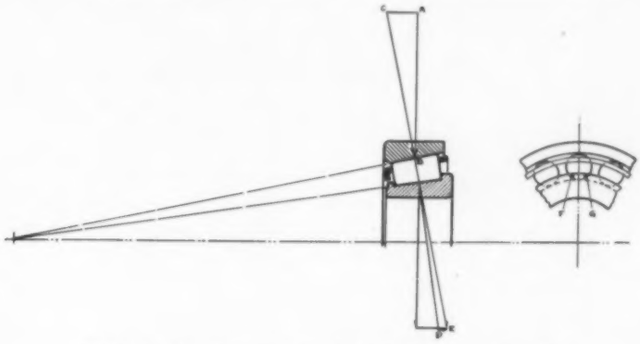

FIG. 1—Bearing with an included cup angle.

stator than in the rotor. The change of flux direction in the stator corresponds to the supply frequency while in the rotor it corresponds to the slip. With some types of construction the expansion of the frame of the motor is slightly greater than that of the shaft.

On direct current motors, however, the conditions with respect to flux are reversed and the construction around the shaft restricts heat transfer. On mill type and traction motors expansion differences as great as .015" have been observed on shafts approximately three feet in length. This type of machine requires a mounting similar to that shown on Fig. No. 3. Two bearings per box mounted in cartridges having sliding fits in the housing bores are used. Where both ends are permitted to float and limited to reasonably small end play by the location of the outside caps, lock nuts on the shaft are not necessary. With a hot metal saw, bevel pinion, or channelling cutter mounted on the extension no endwise freedom is permissible. One of the outer race assemblies is definitely located by the end caps and a lock nut, shrink ring, or other means is provided to clamp the inner assembly at that end against the shaft shoulder.

On some classes of equipment, particularly traction motors, the axial space available is very limited. The cartridges, when manufactured in small quantities are fairly expensive. To meet these conditions our Company has developed and tested a line of self contained, double row, tapered bearings and is now preparing production equipment for their manufacture. These units have ample capacity to carry the loads of all ordinary drives using the smallest size that will go over the shaft extension. They operate successfully at the high speeds used on fans, blowers and centrifugal pumps, and have ample thrust capacity for helical gear drives and vertical mountings.

*Engr. Dept., The Timken Roller Bearing Co., Canton, Ohio.

One of the most extensive uses of our bearings on industrial equipment is on various forms of wheels. A typical mounting is shown in Fig. No. 4. With the bearings mounted in the wheel hub on a dead shaft application, the large ends of the cones are turned away from each other to provide maximum rigidity. Adjustment is made on the inner races by means of a nut and cotter pin. This type of mounting is used mostly on mine cars, industrial trucks and the lighter forms of carriers. On railway

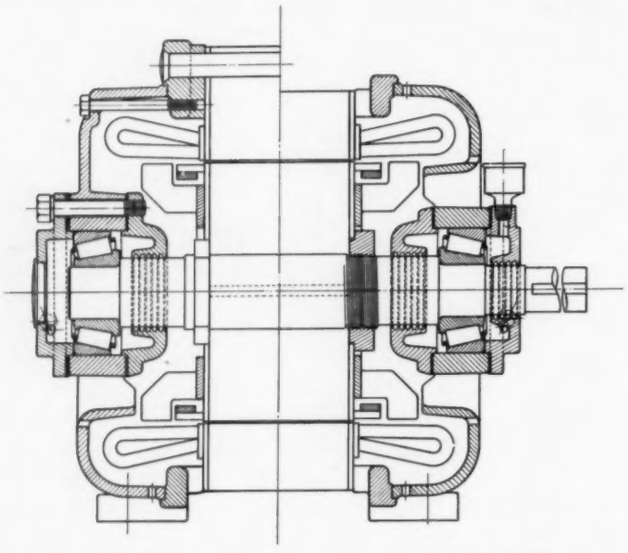

FIG. 2—Single Bearing mounting for Induction Motor.

cars, ingot cars, hot metal and slag pot cars and on all power axles the bearings are mounted in boxes either immediately inside of or outside of the wheel. Either cone adjustment as shown in sketch No. 4 or cup adjustment with cones mounted back to back as shown in Fig. No. 3 may be used.

Extensive applications have also been made to traveling cranes on all the principal positions—drum shafts, back shafts, trolley and bridge trucks and reduction gears. Due to their inaccessibility bearings on cranes are very frequently neglected. Oil is not suitable as a lubricant, as the motion of the crane tends to throw it out of the enclosures. Grease lubricated anti-friction bearings will run from six months to a year without attention, and disagreeable and sometimes destructive drip of lubricant on the runways and on workmen and material on the floor is eliminated.

One of the most difficult applications in a steel plant is the hot metal saw. The calculated loads of this equipment are not as great but the speeds are high and the operation is accompanied by violent shock. Four and a half or five inch bore bearings operating at 1100 to 1500 R.P.M. are by no means unusual. Our mounting uses two bearings per box with the large ends of the cones back to back similar to the arrangement shown in Fig. No. 3.

Differential expansion is taken care of by floating one of the bearing assemblies. Ball seats are sometimes provided on the cartridges containing the bearings. Due to the high speed, lubrication is taken care of by sight feed oilers or by a circulating system driven by a small pump. In some cases, however, grease has been successfully used.

Table rollers present an opportunity for saving in the attendants' time and in the cost of lubricants as the number of bearings involved is large. The service is not particularly difficult except on the feed rolls where considerable shock occurs. An appreciable power saving is possible as bearing losses represent a large per cent of the power input. Small motors for individual drive are being used on several new installations.

There is a great difference of opinion as to the amount of power that can be saved through the use of anti-friction bearings. A ring oiled sleeve bearing running with an established film has a coefficient of resistance of approximately 0.010 while a grease lubricated anti-friction bearing has a coefficient of resistance of approximately 0.005 varying somewhat with different bearings and with different conditions of load and speed. In other words approximately 50% of the bearing losses can be saved. On an electric motor where the bearing losses seldom exceed three per cent of the power input the saving will not exceed 1½% of the power consumption. The use of anti-friction bearings on this class of equipment results from greater dependability and freedom from lubrication troubles. In sharp contrast to this is a train of cars moving at constant speed on level track where bearing losses represent a considerable portion of the power input to the equipment. The saving here is a large item.

On many sleeve bearing applications, however, the oil film is very imperfectly maintained. Shafts that start and stop frequently lose the film with every

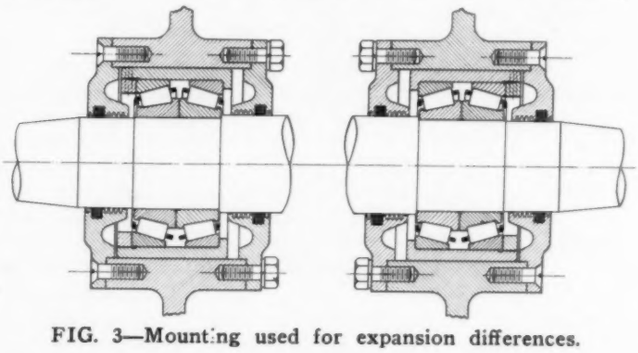

FIG. 3—Mounting used for expansion differences.

stop. Shock loads tend to break down the film. At low speeds the film cannot be established. Waste packing used on bearings on moving members does not function as effectively as oil rings or pressure feeds. The advantages of the anti-friction bearing on applications of this class are much more marked both with respect to power saving and bearing life.

The selection of a suitable grease is a matter of importance particularly on the higher speed applications. The more common greases are compounded with a calcium base soap. Greases of this type melt at about 190°F. Once they have become fluid in an enclosure, they seldom return to the form of grease but tend to separate into soap and oil. Their extensive use industrially is largely the outgrowth of their use on automotive applications where resistance to absorption of water is a factor. Greases compounded with a sodium base soap have a higher melting point than the former and have the decided advantage that they return to grease on cooling from the fluid state. They absorb water readily but for an indoor application, this characteristic is no par-

ticular disadvantage. An oil of not less than 200 seconds Saybolt viscosity at 100°F is desirable. The grease should not be too light in consistency or churning will result.

The recent application of our bearings to main roll necks on a number of mills has attracted widespread interest. The high capacity required and the limitations on space make the problem more complicated than a mere multiplication of dimensions and a careful study of each project is necessary. Our company has been experimenting with roll neck applications for about two and a half years. A

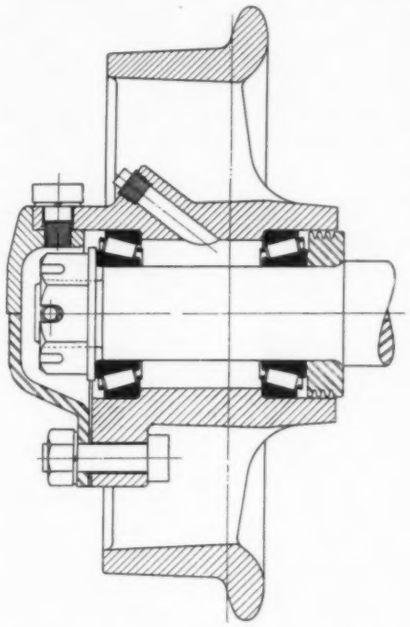

FIG. 4—Bearing for Industrial Equipment.

test installation was first made on a 22″ mill at its plant to obtain a check on the carrying power of large bearings. An installation was then made on a 16″ mill which has now been in operation about nine months without bearing trouble. Bearings have been supplied for roll necks, pinion stands, and gear reduction units on a number of recent installations. A large saving in power consumption is obtained through the use of anti-friction bearings. Tests on the 16″ mill at the Timken plant show an average saving of 44%. A higher grade of product can be maintained due to the greater ease of holding the sections. The saving in maintenance costs, cost of lubricants, and loss of time resulting from the frequent replacements that are necessary when using plain bearings constitute a strong argument for the use of anti-friction bearings on main roll necks and drives.

F. E. Erickson*: Two years ago, at meetings you were in the midst of a standardization of electric motors. Now your committee has completed the general purpose motor standardization and more recently the standardization on the steel mill motor. It is to be congratulated for this work. In a field as specialized as the steel mill industry there is no question but what this work will show most advantageous results—now and in the future.

The question of bearings for mill standardization has been given a great deal of study and thought. Probably all of you have had experience with them or you would not be at this meeting. You know from experience that anti-friction bearings present certain definite advantages. None of you—or at least very few of you have adopted anti-friction bearings for all types of service. Probably the bearing has not entirely proven itself in your eyes.

It seems to me, were I in your position, that which I should be most interested in would be definite knowledge of what has been done with the anti-friction bearings. I should want to know what life can be expected of an anti-friction bearing. I should want to know of examples when bearings had been run under adverse conditions of load, in out of the way places where proper maintenance is difficult. I should want to know how plain bearings with which I am entirely familiar stood up in the same location. I should want to know something about the design of the various bearings.

At the risk of boring you, I want to explain briefly our position as a company in the matter of anti-friction bearings. In the first place we manufacture ball, roller and spherical bearings. That means we are in a position to furnish a bearing for any specific application to put the right bearing in the right place, so to say.

First, we make the self-aligning ball bearing which is the only bearing having the inherent ability of compensating automatically for misalignment or shaft deflections. Misalignment will not cramp or wedge the balls or cause the bearing to heat. The principle of the ball and socket joint is embodied in the bearing itself, eliminating all need of external aligning devices.

Because it is especially well adapted for applications where misalignment is an important factor to be considered, as well as its high radial capacity, the self-aligning ball bearing has found wide favor on general purpose motors for over fifteen years.

The second is the deep grove ball bearing. Because of its construction, it will carry radial load, thrust load, or a combination of the two. It is characterized by its deep, uninterrupted symmetrical groove construction resulting in high thrust capacity.

The third is, the cylindrical roller bearing made as are our other bearings of high carbon chrome steel hardened throughout—with a precision equal to that of all other of our bearings.

The outer race is of cylindrical form with a flat raceway on which the rollers run. The rollers are of the short type, having their length and diameter about the same.

This bearing is made in two types. One having shoulders on both inner and outer races, thus providing for stabilizing the shaft endwise. The second type is made without shoulders on the outer ring, thus permitting the inner ring and rollers to slide through. This type is suitable where endwise stabilization of the shaft is not required and is of assistance in certain types of assembly.

However, neither of the two designs of this type is suitable where housings may be out of line or where there is an appreciable amount of shaft deflection.

*SKF Industries, 165 Broadway, New York, N. Y.

This bearing will carry limited end thrust loads.

The fourth type is, the spherical bearing which has been designed to meet space limitations where greater compactness for a given capacity is required. It is a self-contained unit retaining practically all of the smoothness of operation and low friction qualities of the ball bearing.

In this bearing the outer race is ground to a hollow sphere, which permits of the free self-alignment of the bearing.

The rollers are of barrel shape and each of the two rows of rollers is permitted to operate independently of the other. The retainer may be either of steel or bronze, according to conditions of service, the function of which is spacing or separating the rollers.

The actual guiding of the rollers is controlled by guide rails integral with the inner race. The self-aligning feature of the bearing allows for considerable misalignment without setting up stresses in either the rollers or raceways.

The bearing is capable of accepting thrust loads in either direction.

Depending upon the service, we select any one of these types, each having very definite advantages. In large units for example, we have used a three bearing mounting with the spherical bearing taking the major load, the deep groove taking the thrust and the aligning bearing the outboard radial load.

Generally speaking, however, the spherical bearing lends itself to steel mill work since it has the essential requisites of self-alignment, it has capacity and ability to withstand shock, takes thrust in either direction, and is a self contained unit.

Let me cite some examples of the application of both ball and spherical bearings. I have purposely refrained from mentioning names of any companies whatsoever. I quote from an Assistant Superintendent who has had some experience with pump motor bearings. "On account of trouble experienced with plain bearings from dirt and water we first saw the necessity of totally enclosed bearings. Since in 1909 it was impossible to buy anything but a plain bearing motor it was necessary for us to buy motors made to order. Later some of the older motors were changed over to ball bearings. We now have motors varying from 1 to 125 H.P. equipped with self-aligning ball and spherical bearings. One of the principal advantages of ball bearing motors is the small amount of attention required.

Lubricant costs have been reduced by 92%; bearing repair costs 75%. The saving averages $25.97 per year per motor.

"What is more important than this is the fact that the possibility of disastrous breakdowns is reduced. When rotors strike, stator windings are damaged. The anti-friction bearings eliminate this danger."

Here is another report by a master mechanic:

"We had one 15 H.P. motor equipped with ball bearings. The results so surpassed the plain bearings that we decided to equip our crane and pump motors with anti-friction bearings, the change made by our own repair and maintenance force. Since 1924, we have been able to reduce our maintenance force by three men and our costs are only a fraction of what they formerly were.

"Another advantage of anti-friction bearings is that practically no oil gets out of the housing. With babbitt bearings oil leaked out onto the windings and ruined the insulation. On D.C. motors the oil would also get on the commutator and ruin the mica and cause arcing.

Through the use of anti-friction bearings we have saved $4,356.00 in maintaining the motors."

Let me quote from a Chief Electrical Engineer's report:

"Ring type sleeve bearings have always given us trouble because of oil leakage onto the commutator bars and the winding, our Spherical bearings with their dust and oil proof housings have eliminated this source of trouble, for by employing an Alemite system, and having an experienced lubrication man grease all bearings once a month, we are never bothered with electrical maintenance problems caused by oil leakage into the motor. Our electrical equipment has 50% greater life before overhauling is necessary, as a result of the adoption of Skayef Ball and Spherical bearings. We estimate that we are making a direct saving of 75% in lubricating costs. There is practically no wastage of grease.

"We feel that where their application has been carefully studied and true economies significance placed on their performance in relation to that of the entire machine or process, anti-friction bearings have made a creditable showing in our equipment."

What will bearings do in your power house equipment? The general superintendent of one of the largest in the country writes as follows:

"It has been found the self aligning ball and spherical bearings for motors offer certain very definite advantages. Although every precaution is taken to line up the units there is a possibility of misalignment due to warpage of end bells or inaccurate machining. On reassembly of motors after service inspection, it is possible to bolt up the end bells in a slightly cocked position. Again the mechanic may ridge the break between the motor frame and end bell, which produces the same condition. With certain types of drives a deflection of shaft takes place, as is evidenced by wear at the ends of the plain bearing.

"With self-aligning bearings these possibilities of bearing failure are avoided, since this type of bearing automatically compensates for any condition of misalignment.

"In the last analysis, the absolute reliability of anti-friction bearing motors is one of their greatest assets. When properly designed, ball bearings require practically no attention and the units may be started, stopped or speed varied from remote points with absolute certainty of proper functioning.

"If a pump unit has to be shut down, because a motor needs repair, it may mean that the load on large generating unit has to be decreased or cut out entirely. Since losses from such incidents are most expensive, freedom from such trouble is of utmost importance."

Let us take some of the other important locations in a steel mill where motor trouble is expensive.

"On the traveller motor of an open hearth loading crane we installed bearings three years ago. This motor has been in continuous service and the only

maintenance has been a quarterly lubrication schedule 3 years in a service where plain bearings were renewed 6 times a year." The success of this installation has warranted the specification of the spherical bearing on their new motors.

On another mill the plain bearings on the motor for the reversing table rolls required renewing once every ten days. A changeover to spherical bearings was made, and the bearings have been running for a year. It was not an inexpensive changeover, but it paid for itself in three months. New equipment recently installed was specified with the spherical bearing.

An electrical superintendent recently told me that in his experience it wasn't the large motors that caused him annoyance for they were carefully watched but it was the little auxiliary motors that kept his repair men busy. Take a simple case of man cooler motors. The heat, dirt and speed require constant attention and maintenance. Numbers of these motors have been changed from plain to ball bearing.

An ample oil supply allows them to run for 6 months without attention. The housings are so designed that the oil cannot be sucked out of them.

We could go on and on citing installations, but time will not allow it. One point remains. "What is the basis by which proper bearing service, such as in the cases indicated above, can be secured?"

Well, it is the proper selection of bearings for particular duty involved and secondly proper housing design. The second is easy for it requires one of a number of arrangements which have been proven satisfactory.

The first that is bearing size is of fundamental consideration.

For the past ten years, our company has made an intensive study in the field and in the laboratory of the life of bearings. Our laboratory has run thousands of bearings to destruction to determine exactly how, why and when they fail.

As a result of this study, we have most valuable data for the selection of proper bearing sizes. We know, as a result of these tests, one very important fact which is this. If we increase the load on a bearing by 100%, we reduce the life of the bearing to 1/10 of what it previously had. Similarly, if we decrease the load to ½, we increase the life ten times. In other words, suppose we have a bearing which under a given load will operate successfully for 6 months. By putting on a bearing with twice the capacity, we increase the life to 60 months or 5 years. Unfortunately, the basis of capacity between various bearings cannot be made on theoretical load ratings as given in catalogues, but must be obtained as a result of tests. In other words, an emperical formula would not be satisfactory as a basis of bearing capacities.

Another interesting point is this. With a knowledge of the average load conditions, together with the speed—we can definitely tell the average life of the bearing for any specific application. Naturally, there may be some variations in life due to the bearing and to the load conditions, but the average life can be predetermined. These tables are computed in millions of revolutions which in turn can be translated into years of service when the operating conditions are known. For example, in the checking of bearing sizes for the steel motor standardization, we found that using the crane ratings—and assuming average conditions of service that the average life of the bearings will be about ten years—on the smaller sizes slightly more and on the larger sizes slightly less.

Ten years on the average for steel mill, motor bearings, gentlemen, coupled with their low maintenance costs, ease of lubrication, and absolute reliability, will result in a return which you as operating engineers always on the lookout for a suitable return on your company's investment will find attractive.

D. M. Kelly*: The Youngstown District was one of the first, if not actually the first district to go into the roller bearing idea for steel mill equipment. It was here in Youngstown over twelve years ago that Mr. F. E. Kling, Chief Engr. of the Ohio Works conceived the idea, and decided to incorporate trial bearings onto a 14" billet mill roller table.

At that time the installation was looked upon by everyone as a radical departure from the usual method of procedure, but Mr. Kling persisted in making the installation and conducted comparative tests between plain bearings and the roller bearings which were installed These power tests showed possible a saving of 60% in power required to operate the tables after roller bearings were installed.

The power saving possibilities were therefore definitely determined, as was also the operating econ-

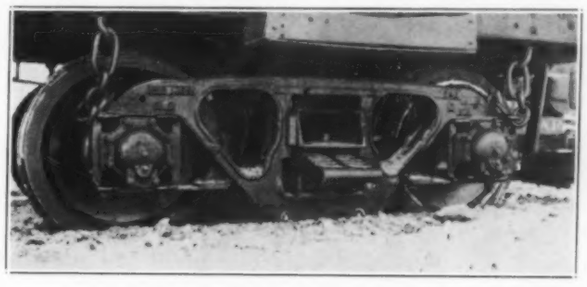

FIG. 1—Railway car journals.

omies in the way of maintenance, since after two and one-half years of service, the roller bearings showed no appreciable wear, and no attention other than lubrication had been given to the equipment.

The decision was then made to include our Bearings into all tables which were to operate on the new bar mills built at McDonald, Ohio, and engineered by Mr. Kling.

Mr. Kling was also one of the first to go extensively into the application of roller bearings to open hearth rolling stock, and at Ohio Works, dynamometer car tests were conducted over ten years ago between roller bearing equipped open hearth cars and cars which were equipped with ordinary bearings. The results secured were better than had been expected, and the tests definitely proved the advisability of equipping this type of rolling stock in order to secure the advantages which were apparent.

Since this first billet mill installation and the operation and tests on ingot and charging cars, de-

*Hyatt Roller Bearing Co., Pittsburgh, Pa.

velopments have been rather rapid, so that at present time there are in operation, with our Bearings included, over ten thousand open hearth cars; the main tilting tables on 14 plate mills; the various tables on 20 bar mills; 7 strip mills; 4 blooming and billet mills; 7 structural mills ranging in size from 13" to 52", and various other miscellaneous tables on individual mills of this same type.

FIG. 2—Roller Bearings used on wire blocks.

Economies secured on equipment of this nature pointed the way to further economies on other types of steel works machinery, so that hot and cold saws, gear reductions, belt conveyers, plate castors, rotary shears, cranes and electric motors were gradually considered as equipment worthy of special attention for the application of roller bearings.

It is but natural that with such rapid development on different classes of equipment, difficulties in the operation were encountered, some of which were serious, some not serious, but all of which led to better designed bearings more capable of giving real performance under the operating conditions;

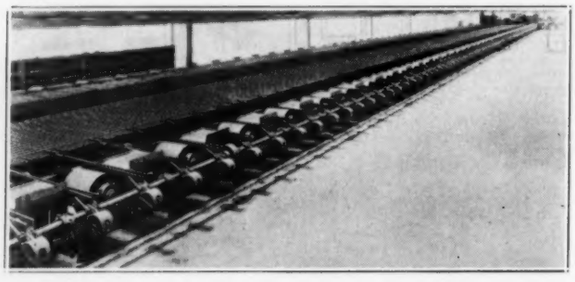

FIG. 3—Roller Bearings used on Griffith Type Bar Mill Cooling Bed.

standardized sizes which permitted more economical manufacture, and tended toward lower first cost of bearings, and of the installation.

The Hyatt Roller Bearing Company thanks the various engineers for pointing out the difficulties which led to the development of better bearings, and better methods of installation, and it is undoubtedly true that the manufacturers of any auxiliary equipment for steel works machinery, have been able to progress by virtue of the co-operation, ideas and assistance of you engineers and mechanics.

The most recent developments include the application of our Bearings to mill, crane and hoist motors. Before entering the motor bearing field we found it necessary to do considerable experimenting, not only in our plant, but in the steel plants where actual operating conditions would be encountered. We found that this class of service required a bearing made after our idea of the helically wound rollers, but other details of design were necessary.

We started out over fifteen years ago with bearings of various designs and applications on railway street car motors in cities, such as Baltimore, Newark, Schenectady, New York City, etc., while some of the first crane motors were installed at the Steel Company of Canada ten years ago, and bearings installed at that time are still giving excellent results on these motors.

Various plants have more recently, due to your design to cut down maintenance and upkeep, changed over existing motors from the ordinary sleeve type bearings to roller bearings, and at the present time there is available from the Crocker-Wheeler Com-

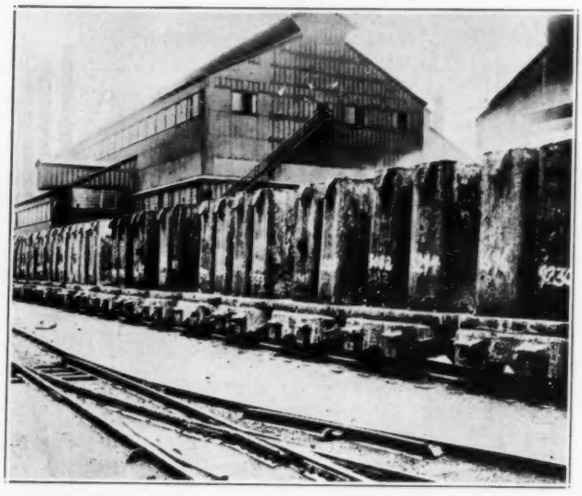

FIG. 4—Roller Bearings used on Ingot Car.

pany, and W. E. & Mnfg. Co., and assemble on existing motors after a few slight changes are made to the present construction.

In addition, the motor manufacturers will furnish you our Roller Bearing equipped motors on specification—bearings installed both on the armature shafts and back axles. The motor manufacturers realize, we believe, that the experimental stage on this equipment has been passed, because of the excellent service records secured on thousands of motors that have operated for several years.

More recent installations include the various General Electric and Crocker-Wheeler motors installed at the Illinois Steel Company on locations of the new blooming mill; the crane motors for the Sparrows Point Works of the Bethlehem Steel, built by Westinghouse; the Crocker-Wheeler crane motors at Bethlehem Steel-Lehigh and Saucon Works; Central Steel Co., Massilon, Ohio Crocker-Wheeler motors throughout the coke plant; Gen. Electric Motors on Trumbull Steel Company hot bed, etc.

At the present time a large percentage of the steel plants in the United States and Canada have installed our Bearings on motors, either onto new motors purchased, or on existing motors, the latter type of installation being made in order to determine future motor bearing policies and operating characteristics.

Perhaps the first real effort to apply Roller bearings to cranes was made here in Youngstown by Mr. A. G. Place of the Youngstown Sheet & Tube Company, who as most of you know, recently purchased several cranes for both the Youngstown and Indiana Harbor Plants completely equipped with roller bearings, including the motors and back axles. Although all of these bearings were not of our manufacture, nevertheless we feel that any development or progress made in the application of roller bearings helps along the Steel Mill Industry.

Cranes which have been built include standard overhead traveling cranes, 150-ton ladle crane, 75-ton ladle crane, and various special cranes, open hearth charging machines, etc.

The type of our bearing furnished for crane and motor applications is identical in construction

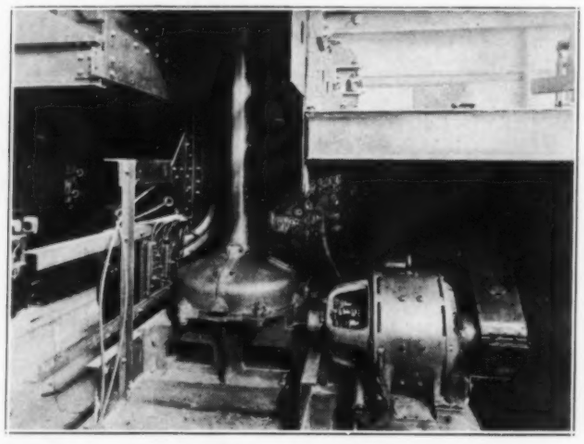

FIG. 5—Roller Bearings used on the Paff 22" Wire Drawing Block.

and design, so that very often crane bearings are interchangeable with armature and back axle bearings.

The various types of machinery and equipment which you use in the steel industry are all subject to severe service, in some instances heavy normal loads and shock loads at slow speed, light loads at high speed, heavy loads at moderate speed, etc., and in the various installations, which we have made, effort is expended to determine accurately the type and class of service in order to make a selection of the correct installation and application of the most economical bearing type.

Another item of direct interest is the application of roller bearing to roll necks on various types of mills, which has in some instances undergone considerable development, and on our own part still in the experimental stage as we are proceeding with the same caution as we have exercised when approaching a problem of such magnitude.

A more recent development not directly connected with your steel plant operation, but of considerable interest to you, embraces the railroad field, where the same caution and experimental work has been expended in order to put the correct bearing in the right application.

After operating on an interurban line at Cedar Rapids, Iowa, for over 175,000 miles, our Bearings which were installed proved to be in the same perfect condition as when the original installa-

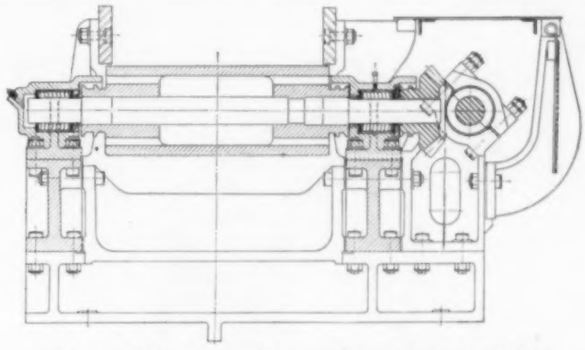

FIG. 6—Roller Bearing used on Runout Table.

tion was made. Other such service records have been secured on railway tenders, and local street car lines.

This class of service parallels many of the operating conditions encountered on other equipment and it is significant, that many of the leading railroads are installing roller bearings onto standard railway cars and coaches

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D. E. Batsole*: The outstanding achievement during the past two years in the anti-friction bearing industry is, without question, the greatly extended field of application which has been opened up to the use of such bearings. While the consideration of new application problems has naturally demanded new bearing designs in some cases, still the changes in bearing construction have been comparatively few. In most instances the problem has been one of bearing mounting; protection and lubrication, rather than one of bearing design.

The rapid development which has been made recently on new and hitherto untried applications has been due, no doubt, to the increased confidence of the engineer in ball and roller bearing performance where a proper study has been given to the problem. This confidence has been strengthened in many cases by the satisfactory operation of such bearings over a period of years in one or more pieces of machinery in the modern plant.

In order to illustrate the greatly deversified range of application of precision roller bearings, we would mention first the matter of speed. For example, roller bearings are used in large and ponderous moving parts such as dam gates, valves, etc., where the rotational movement is barely perceptible to the eye. On the other hand precision roller bearings are now in operation at extremely high speeds, in fact at speeds which were unthought of several years ago. On airplane superchargers for instance roller bearings are being operated at a speed of 36,000 R.P.M. When it is remembered that this means a speed of 600 revolutions per second and that the rollers themselves revolve at the rate of approximately 1800

*Asst. Engr. Mgr., Norma-Hoffmann Bearings Corp.

revolutions per second on their own axes, it seems almost unbelievable that such speeds can be attained. This speed can be accurately checked, however, as these supercharger shafts are gear driven directly from the engine crankshaft. While such applications are, of course, far afield from anything in steel mill practice, they are only mentioned to illustrate what is being done in the direction of increased speed.

Another great contrast in the field of roller bearing development is that of roller bearing sizes. These

FIG. 1.

range from light series roller bearings of only 10 millimeter bore, that is approximately three-eighths of an inch, to heavy duty roller bearings for rolls and similar equipment and running up to 20 and 24 inch bore. We have been rather surprised to find such a large demand for roller bearings of the smaller sizes during the past few years as we had thought that bearing sizes below two inches would be almost uncalled for. These small roller bearings are applied mostly to motors, blowers, compressors and reduction gear units of small size.

One of the problems which arise in almost every case where cylindrical roller bearings of the type

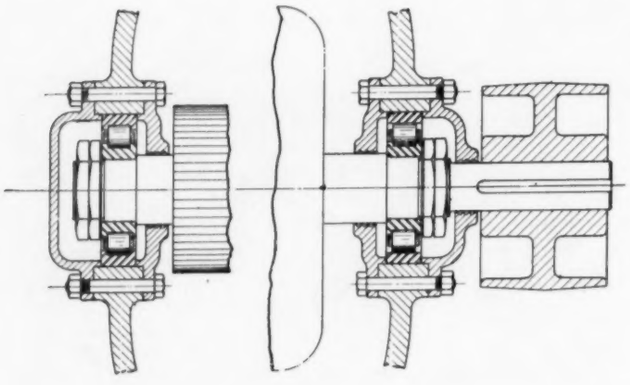

FIG. 2.

shown in Figure 1 are used is that of taking care of end thrust. It will be obvious that a bearing of this construction cannot carry any thrust because there are no shoulders in the outer raceway. On the other hand such a bearing allows for expansion or contraction of its shaft because the rollers are free to move across the face of the outer raceway. This same bearing is also supplied with shoulders in the outer ring which makes it self-contained. Such a bearing has sufficient thrust capacity to take care of the location of the shaft where a spur gear, chain or belt drive is used.

Figure 2 illustrates a motor equipped with a two lipped or self-contained bearing at one end of the shaft and a cylindrical bearing with no shoulders

FIG. 3.

at the other end. This combination permits of rigid clamping of the outer rings of both bearings as the expansion of the shaft cannot cause binding of the rollers endwise. The design furthermore permits of interchangeable housings and cover plates, some-

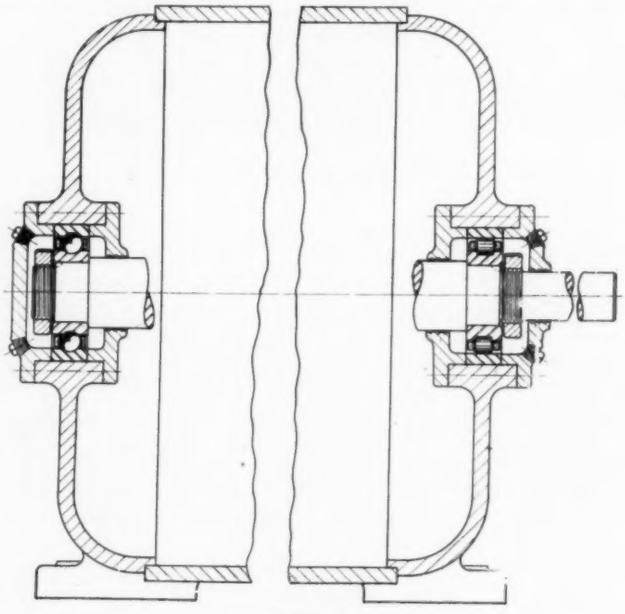

FIG. 4.

thing which is quite desirable where quantity production is concerned. Figure 3 shows a Roll Out Table motor which is equipped with roller bearings of the types just mentioned.

Another mounting for motors of the smaller sizes is shown in Figure 4. In this design a single row

closed type ball bearing is used at the commutator end of the motor to position the armature and carry the radial load at this end. Such an arrangement of bearings is suitable for use on a vertical as well as a horizontal motor except that the problem of

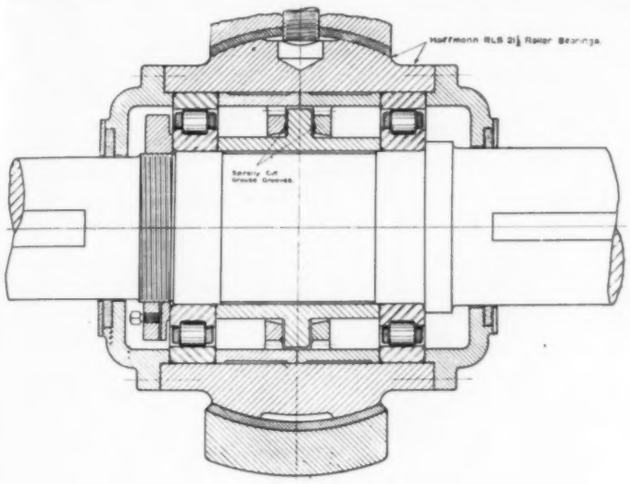

FIG. 5.

retaining the lubricant in the vertical motor is a more serious one. This combination of a ball and roller bearing on the same armature shaft is suitable for motors up to approximately ten horsepower. For larger sizes the combination of bearings described in the preceding paragraph should be used except in the case of vertical motors. The usual

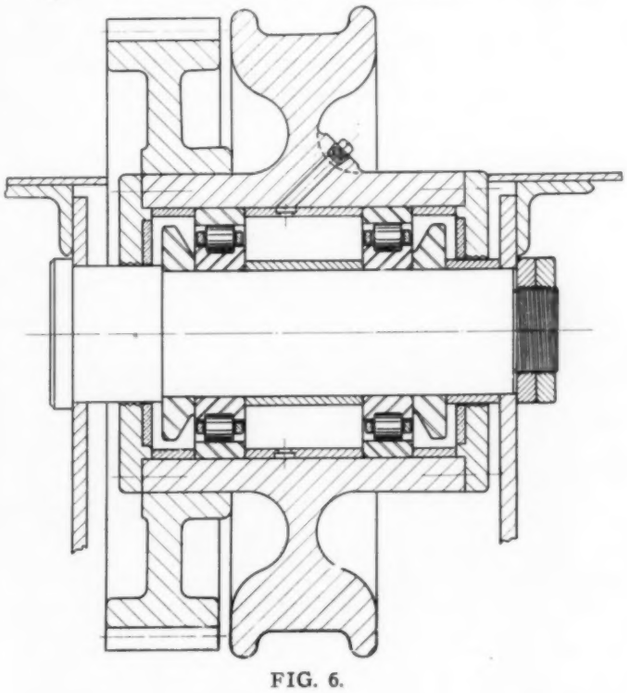

FIG. 6.

construction for larger vertical motors consists of two roller bearings, one at each end of the shaft, and a ball bearing at one end to carry the thrust.

A common method of locating a shaft endwise is by the use of thrust washers or thrust plates. Figure 5 shows a design of housing which is mounted in a self-aligning support. The thrust is carried on the ground flanges of the rotating and two stationary spacing bushings between the roller bearings. To insure adequate lubrication a number of holes are drilled through the outer flanges and in some instances, a spiral groove is turned in the inner surfaces to better distribute the oil to all points. Where two such bearing boxes are used on a shaft, the

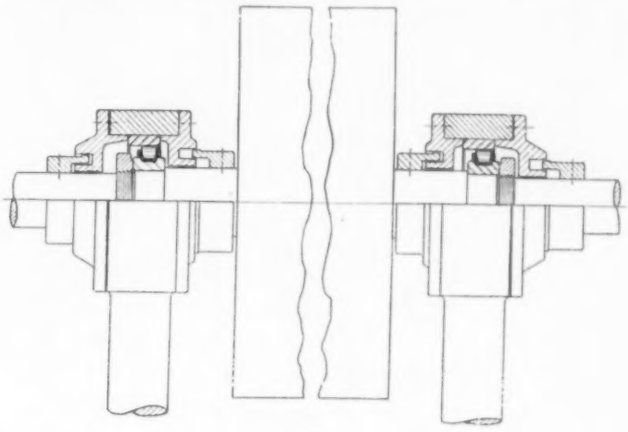

FIG. 7.

bearings in the other box do not require the thrust flanges as they must be allowed to float to take care of possible expansion.

A variation on the above mounting is that shown in Figure 6. This is a crane wheel application and it has been designed to permit endwise movement of the wheel to allow for variations in width between rails. The roller bearings being located in the hub of the wheel are always in accurate alignment, whereas if the bearings were located outside of the wheel, they would have to be of the self-aligning type to give the best results. The end thrust is taken between the rotating flanges located at the side of each bearing and the bronze plate which is inserted in each of the cover castings. This design permits of an endwise movement of the

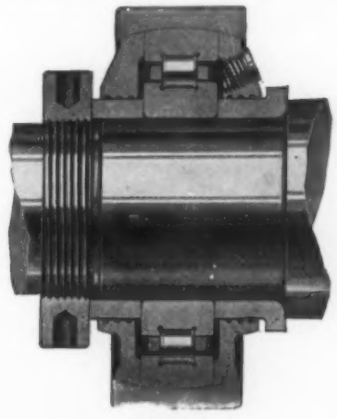

FIG. 8.

wheel of about ½ inch each way from the central position. If a greater movement is desired bearings are supplied with special wide outer rings.

The possibility of endwise movement of the rollers in the cylindrical roller bearing has been taken advantage of in a rather interesting application shown in Figure 7. This construction has been used

on a machine where continuous oscillation and rotation have been combined, both being carried on at relatively high speed. The bearings under this kind of service do not show wear, although it is essential that the ends of the rollers be ground and lapped to a smooth finish in order to reduce the friction when the shaft is moved endwise. The so-called

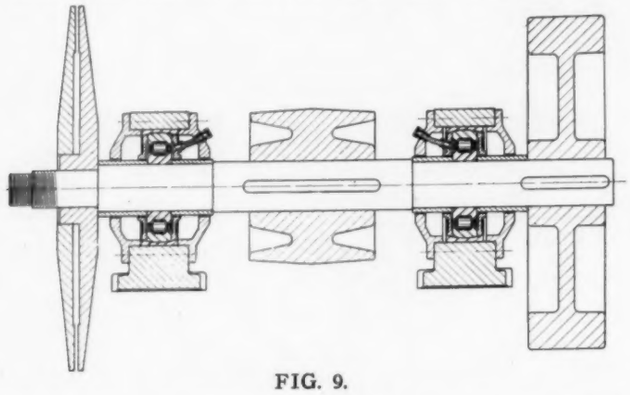

FIG. 9.

"labyrinth" system of protection has been carried out here, by the use of long flanges extending into deep grooves turned in the cover plates.

A special form of roller bearing shown in Figure 8 has found a wide spread field of application. This bearing is of the self-aligning type with an outer

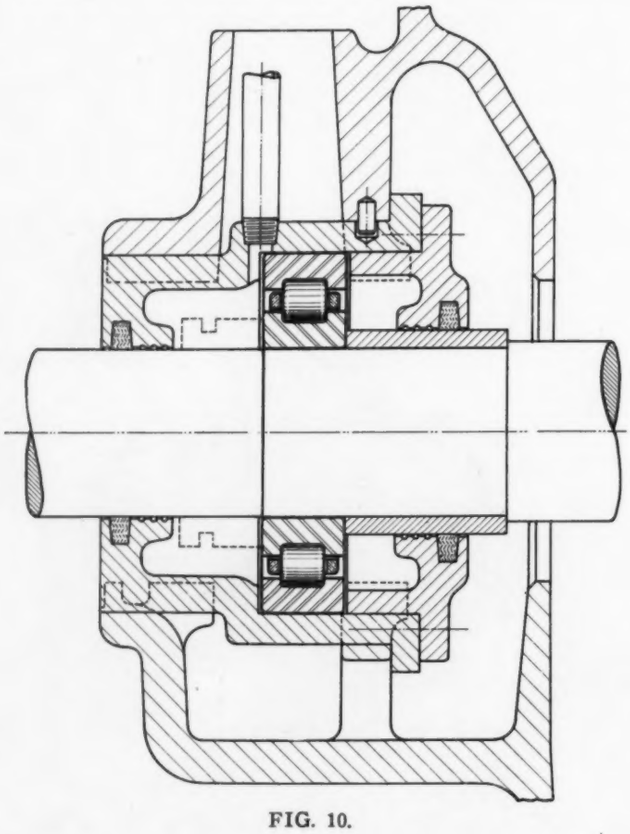

FIG. 10.

shell forming in effect a ball and socket. This outer shell also encloses two cover plates which provide protection from dust and dirt and at the same time hold the lubricant in the bearing. Naturally these side plates will always align themselves with the shaft in whatever position it may take and therefore a close running clearance may be provided where they fit over the shaft. The use of such cover plates makes it unnecessary to provide felt rings or any other kind of flexible protection such as is usually required with a self-aligning bearing. Each cover plate is provided with a threaded opening through which grease may be applied directly to the running parts of the bearing. A bearing of this type is very economical for use where only a few bearings are required, as it makes unnecessary the providing of elaborate cover plates unless the conditions of dirt or moisture are particularly bad. Ordinarily the cover plates are sufficient protection for the bearing. This same form of bearing is sometimes equipped with adapter sleeves for line shaft applications.

Figure 9 shows quite clearly how these bearings may be applied under conditions of extreme dirt or

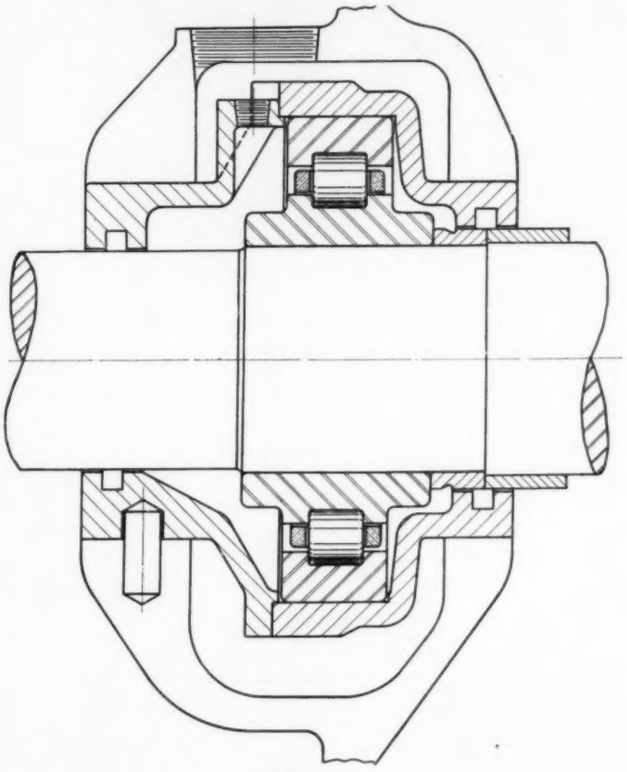

FIG. 11.

moisture. The illustration shown is that of a hot saw. A secondary protection is provided by the housing cover plates which, of course, do not have a close running clearance around the shaft. Grease is inserted by means of a pressure gun directly into the bearing through the flexible tube shown. Even under the most dirty operating conditions it is impossible for any foreign matter to penetrate to the rollers and their raceways. Naturally one of the bearings is allowed to float in its housing to take care of expansion of the shaft while the other is clamped in position. This particular application was used to replace sleeve bearings which had to be renewed on an average of once every two months.

As to the matter of steel mill motors and their bearings much has been said in various papers presented from time to time, so that it is unnecessary to comment further in this article. Figure 10 illustrates one form of the popular "cartridge" mounting

for a mill motor, this design having been made up to replace sleeve bearings previously used. The original form of the casting is shown by the dotted lines. The same construction may be used at each end of the motor either with or without the shrink rings as indicated. For protection felt rings and

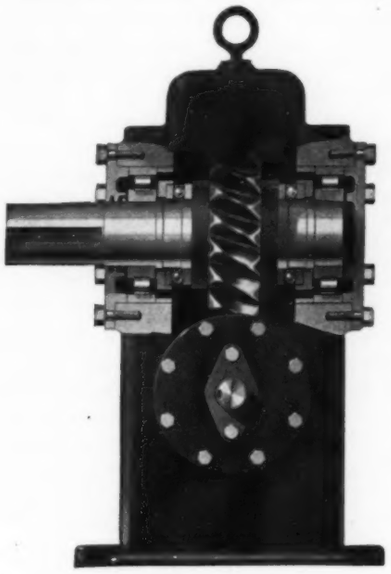

FIG. 12.

also shallow grease grooves may be used, but if felt is employed it should be of good quality and properly fitted, otherwise its value as a protection is nil. A somewhat similar mounting using a wide inner ring type of bearing is shown in Figure 11.

Another rapidly growing field for roller bearings is that of reduction gears and gear drives of various

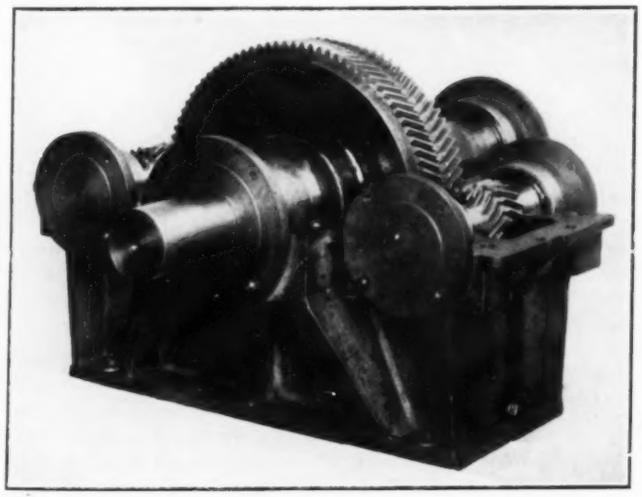

FIG. 13.

kinds. Figure 12 illustrates a roller bearing mounting for the worm gear shaft of a worm reduction unit. The thrust of the gear teeth is carried on ball thrust bearings of the standard type and mounted one at each side of the worm gear. The use of roller bearings on such applications reduces the overhang of the shaft and makes a much more compact unit. The gear case is partially filled with oil, which also serves to lubricate the bearings. On the worm shaft of such large units, roller bearings of the usual type are used at each end of the shaft with a roller thrust bearing to carry the heavy thrust loads due to the worm.

A herringbone reduction unit is shown in Figure 13. This is a duplex unit with two power input shafts, which together with the take-off shaft are mounted on roller bearings. The gearcase is split horizontally through the center lines of the gear and pinions. To take care of the heavy loads imposed on the overhung gear shaft, two roller bearings are used. All of the bearings are of the standard or separable type, with the location of the large gear being taken care of by means of shoulders machined on the housings and bearing against the hub of the gear.

It is impossible of course in an article of this length to dwell upon all of the greatly diversified applications in the steel mill. We have endeavored in the foregoing to cover briefly only a few of the new and more interesting developments of the past few years. The use of anti-friction bearings particularly roller bearings in the steel industry has increased with great rapidity and it will be interesting indeed to observe the progress along new and hitherto untried lines which the next few years will bring forth. It is certain that remarkable results will be obtained if a sufficiently careful study is made of each application before bearings are recommended and installed.

H. E. Reynolds*: Development in material and methods in the ball bearing field have been very rapid in the last two years. Changes in material and design have been made that have greatly increased bearing capacity. New applications of Ball Bearings to industry have been most successful. This your speaker knows is not only true of his product but is also true of the rest of the Ball Bearing peoples. At first planned to confer with associates in the preparation of this article, but conditions out of control made this impossible. As

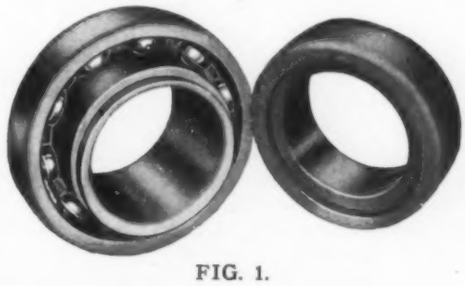

FIG. 1.

a consequence only the developments of the Fafnir Bearing Company will be discussed and here we will again divide our results and take up only the development of our industrial type bearing.

I'll not take your time bragging about the different jobs we have successfully handled nor will I talk very big about our failures, what I wish especially to call to your attention is first, the modern ball bearing is through the use of better materials and larger balls a much superior article to our product of two years ago. It still requires the same care

*Chief Engr., Fafnir Bearing Co., New Britain, Conn.

in handling, however, and requires careful housing design to keep out the dirt. This is especially true of a standard radial bearing.

At the time I addressed your Chicago Meeting there were quite a few of the members present who will remember at that time I introduced a bearing which we called our Industrial Type. This bearing is developing very successfully and has been applied to almost every type of machine or motor. It is on high speed wood working tools, attrition mills,

FIG. 2.

on wood hogs, in the cement mills, on cranes and pulverizers and even in one or two places in rolling mill service.

We have made it in the extra heavy size up to 5" shaft diameter and in the medium rings up to 7". Right now we are building a lot of 5-15/16 single pillow blocks as a second order for pinion shaft drive for a rolling mill job.

There are two conditions in the mounting of standard ball bearings which make their industrial application difficult. With this bearing of ours we overcome these conditions. First a standard bearing has a metric bore, our bearing is bored to inch diameter, second, the narrow width of a standard ball bearing requires that first it be pressed on against a shaft shoulder to square it up, and second that it be a press fit to prevent shaft peening under load, due to its capacity in proportion to inner ring widths.

First conceived as a line shaft bearing we quickly appreciated its possibilities as a bearing for industries' use where conditions of design not only made the application of a standard radial ball bearing difficult but in some cases impossible. With our wide inner ring we don't need a shaft shoulder. The ring length insures squareness with shaft axes, neither do we require the press fit. Our complete application is the reverse of that of the standard radial bearing. We float our inner rings and also prefer to float our outer. On occasion, however, these bearings are mounted as standard radials are mounted with excellent results.

Fig. 1 shows its application to a loose pulley. Here a load is usually very light. This is especially true where productive machinery is stopped and started only once or twice per day. As a loose pulley application, it shares with other ball bearings all their regular advantages plus a much greater ease of application.

In most cases the poorest of ball bearings will make troublesome loose pulleys behave. The excuse for using our product being its ease of assembly and a quality which will, without fail, take care of any condition. An idler is a loose pulley put to work—here service is continuous and sometimes severe. We sell and recommend our light bearing for loose pulley, but for idler service request your specifications as to speed and load, and what you would consider satisfactory length of service.

Fig 2 shows the side elevation of our unit aligning pillow block. This also brings out the method of our application and shows our thrust collar. The outer ring of the bearing, you will note, is fitted into a spherical seat in the housing. This allows that initial alignment so necessary if ball bearings are to be successfully applied as separate pillow block application. The inner ring is bored a close fit to the shaft and by an eccentric interlock is gripped by its collar. Two of these bearings are required to hold the shaft in position.

Collar should be mounted on opposite sides to take care of thrust loads from either direction.

Fig. 3 shows the two end bells of an electric motor. Here the convenience of this bearing is strikingly brought out. Note the simplicity of applications and the absence of trouble making features Each end bell is made from the one pattern —both are completely sealed against dirt. They may be removed with their bearings as a unit and straight shafts with no weakening by shoulders are used.

Due to the value of interchangeability, this bearing is not recommended by us for new motors, as

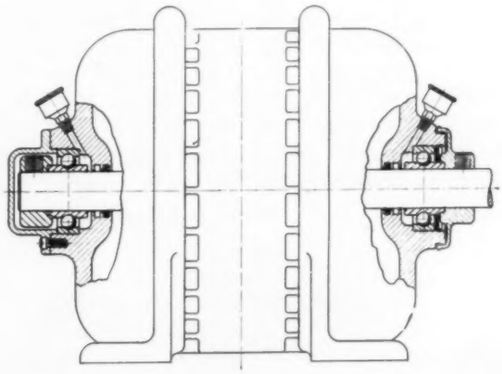

FIG. 3.

one of the points in favor of ball bearing motors, is the fact that ball bearings are standard and interchange.

The bearing I have described is standard only with us and while it is largely used by machine builders, it does not as yet interchange with any other bearing except at the outer ring.

It makes a wonderful replacement bearing. We are prepared to furnish it in shaft sizes from 1-1/16 to 7" and in the light and heavy, for single and double pillow block to any pattern.

We have patterns for all standard line shaft hangers. We also have a large number of patterns for general purposes—electric motor end bells, which are completely interchangeable with the plain bearing pattern.

Due to the variations of end bell design, however, we are always forced to check up that we make sure motors of the same make and size are equipped with identical end bells.

DISCUSSION

R. S. Shoemaker*: The several papers and the discussions we have listened to today have been intensely interesting and instructive. I believe, we may now consider ourselves up to date in so far as the application of anti-friction bearings to motors is concerned. I do believe, however, that to make this meeting complete, that we should ask each of the speakers to come back for a few minutes and tell us something of the more recent applications of anti-friction bearings to roll necks.

I have been informed that a number of three and four high strip and plate mills have been built with large diameter anti-friction bearings on the large or backing up roll necks.

It is my understanding that these installations have been made primarily to save power and to aid in producing a more uniform gauge strip or plate.

The betterment in gauges is accomplished through the elimination of expansion of the roll necks which would be present from frictional heat when using standard brass bearings.

J. M. Kelly†: As far as the application on roll necks is concerned we haven't done much with it, as it means special equipment to manufacture the large sizes of bearings required. We are experimenting along this line to equip the roll necks on smaller mills such as 8" and 10" rod and skelp mills of the Morgan type.

On the 4-high mills the manufacturers, namely United Engineering & Foundry, Mackintosh-Hemphill Co. and Mesta Machine Co. can give you complete information, while on 4-high cluster mills, E. W. Bliss Company has built many of these with anti-friction bearings on the roll necks.

There are a number of mills being put in at the present time with anti-friction bearings on the roll necks, one of the first being that built by United Engineering & Foundry Co. at the Rome Wire Company, Rome, N. Y. The Youngstown Sheet & Tube Co., Lukens Steel Co., Allegheny Steel Co., Laclede Steel Co., Columbia Steel Co., Weirton Steel Co., Trumbull Steel Co., and American Steel & Wire Co. are all installing mills which will have anti-friction bearings incorporated on the roll necks, and most of these mills for rolling strip or wide sheets.

One of the first 4-high mills was the 204" plate mill built by United Engineering for the Lukens Steel Co., but of course the backing up rolls on that mill were equipped with ordinary mill type plain bearings, built in the 4-high type to give a uniform thickness of plate, and take the spring out of the body of the rolls.

There are a number of companies interested in anti-friction bearings for roll necks, not only on these smaller mills, but also on larger mills such as sheet mills, but as yet the Hyatt Roller Bearing Company has not been able to meet the sizes required.

D. E. Batesole‡: Up to the present time we have not supplied any of our roller bearings to roll necks, although we have been told by engineers working on this kind of equipment that successful results have been obtained up to the present time on such applications. Just what we will put out for this purpose, we do not know. It would appear, however, that the bearing which we will submit for use on roll necks will be a bearing made up of a series of rollers having the same length as diameter. To take care of end thrust, we will probably recommend the use of double direction roller thrust bearings in one box on each of the backing-up rolls. The roller bearings in the opposite box will, of course, be free to shift endwise with expansion and contraction.

F. H. Buhlman*: In discussing bearings for roll necks of rolling mills, there unfortunately is little actual operating data to go by, this particular application of anti-friction bearings being of too recent a nature to make this possible. The indications to date, however, are that these installations will be successful both from a mechanical and economical viewpoint.

To give an idea of what the problems to be met are, the following dimensions covering a bearing for the backing up roll of a 4-high mill may prove of interest. The neck on this particular roll is 18" in diameter, the loads run in the neighborhood of 1,200,000 pounds per bearing, the diameter of the Rollway Bearing would be approximately 28¾" with a length of approximately 12". The races are so designed as to allow for maximum possible expansion, which is very necessary in this class of work particularly on mills running on hot metal. The thrust which comes from the crossing of the rolls is taken care of by a separate thrust bearing on one end so that the roll is perfectly free to expand or elongate axially. The maximum speed on most of these mills run in the neighborhood of 25 R. P. M. On another and smaller installation the neck will be approximately 15". In this case the diameter of our bearing will be about 22".

The problem for the anti-friction bearing manufacturer in these roll neck applications is the great radial loads to be contended with, which are much greater than anything that is ordinarily required in the anti-friction bearing field. In fact, to the best of my knowledge, and I believe my confreres in the manufacture of anti-friction bearings will agree with me, bearings of such capacities have not been called for commonly.

There are two methods of making these roller bearings. In one case a bearing of our Maximum type would be used; that is a bearing having rollers that are square, diameter and length being approximately the same. The application of this type of bearing to roll necks would increase diameters to such an extent as to make it necessary to put the bearings in a spool or dumb-bell type of housing; that is, with bearings mounted outside the supporting frame. On account of the limitations in diameter, with even this concession, it is unpractical to get a large enough bearing in and also properly distribute the loads. Therefore, we do not approve of this practice and have made certain changes in our bearing to adapt it particularly to this work. The rollers are lengthened and guided in alignment by a very rugged type of separator. In order to get the necessary capacity, two rows of rollers are used, a common outer race can be used for both roller assem-

*Supt. of Maintenance, American Rolling Mills, Middletown, Ohio.

†Hyatt Roller Bearing Co., Pittsburgh, Pa.

‡Assist. Engr. Mgr., Norma-Hoffmann Bearings Corp., Stamford, Conn.

*Engr., Rollway Bearing Co., Inc., Syracuse, N. Y.

blies; the inner race being preferably split in two sections. This is done to avoid the danger of crystalization at the fillit, a provision which we found to be advisable from experience over a considerable period of time in MCB or railroad practice. With a bearing of this type the alignment has to be taken in the housing rather than in the bearing.

As we see this proposition, there are no particular difficulties involved, the trouble being entirely that of "getting enough radial capacity" or in everyday language, "enough metal under the load" to safely carry it and provide sufficient safety factor to insure its working over lengthy period of time. On earlier installations it is my understanding that the inner race was put on a light tapping fit on the roll neck and one or two inner races broke we believe for this reason. We have therefore, adopted the practice of backing up the inner race by making same a force fit on the roll neck.

The thrust bearing which is a single roller assembly type, designed to take thrust in either direction, of course is larger in capacity than necessary; the size of the bearing being determined by the dimensions of the neck of the roll. It, however, could be considerably smaller, but manufacturers and operators are against reducing the diameter of roll neck at this particular point.

In addition to the applications mentioned, we have under consideration applications for cluster mills and a large hot plate mill which I hope to have an opportunity of incorporating in the form of a paper for the "Iron & Steel Engineer" at a later date.

F. E. Ericson*: I do not know that I can add very much more to what I have already said. In this country, our applications on roll necks are still in the experimental stages. In Europe a number of very successful mills are in operation. The Witkowitz installation referred to by Mr. Wales in this morning's session, has proven, of course, very satisfactory.

To take care of the special requirements surrounding roll-neck installations, we have designed a bearing between the light and medium series, having a greater width, consequently a greater capacity. This is a self-aligning bearing similar to our standard spherical bearing. On account of the large diameter at the roll neck, if a standard bearing were to be used, too large an outside diameter of the bearing would be obtained. In other words, there is, of course, a fundamental difference between plain bearings now used on the rolling mill and anti-friction bearings. In the case of the plain bearing, you have a comparatively long bearing having a small outside diameter, whereas with an anti-friction bearing you get a short length along the shaft with a large outside diameter. Since the rolls themselves will not permit of the standard bearing, it was necessary to design the special spherical bearing to which I refer.

It is the spherical bearing which is employed on the Witkowitz Mills, and has been used very successfully at the Hofors Plant, which, by the way, manufacturers our steel. It is my understanding that spherical bearings have been installed in a wire mill in Scotland, where the cost of the installation was about $9,200, and the saving in power, lubrication and maintenance, over a period of one year, was about $8,800, or there was almost a full return of the money invested after one year's operation.

In this country we have installations on back-up rolls, which, although they have not been in operation for a very long time, appear to be operating most successfully.

One problem on which we are working at the present time involves the accurate axial stabilizing of rolls. This we are doing with a self-aligning unit, and the indications are that it will be comparatively successful.

It so happens that we have just received a bulletin on what has been done on anti-friction bearings on roll necks in Europe, dealing mostly in power saving, that being of prime importance in Europe and particularly in Sweden, where a tree must be planted every time one is cut down. A large number of tests have been conducted which show a very considerable power saving through the use of a spherical bearing. Should you desire a copy of this bulletin, I shall be very glad to have it sent to you.

Mr. Knotts*: The other speakers have told you all I know. We buy roller bearings, we do not make them. Will have 104 roller bearings in use in 26 mills, and will also require roller bearings for spares. In the rolling mill business we do have spares. One mill that has 22" necks, as we call them. (We call a journal on a roll a neck, haven't any reason for it.) The diameter of this journal ordinarily is 22". If you put in two or three or four roller bearings you have to make the neck longer. We have a mill ready to ship to Lukens partially pulled down in the shop, and the reason I agreed to say something today was that if anybody is interested you are welcome to come down and look at it. Bearings in place are protected from oil and grease getting into by packing rings, the same as steam cylinder, and you can't see inside. We had the mill set up for inspection and no roller bearings in it, but nobody knew it, the roller bearings were not delivered. We have been using roller bearings for a long time, but not on roll necks; on roll tables, manipulator parts, etc., all kinds Timken, Hyatt, Hydraulic and ball bearings.

Phelan McShane†: I have enjoyed the meeting very much and have found the papers very interesting. I should also like to take this opportunity to congratulate and thank the committee on the very excellent manner in which the meeting has been arranged for and conducted. As stated by one of the speakers, the motor manufacturers are in position and do supply either anti-friction or sleeve bearings. The motor users and the manufacturer of motors are in a very similar position, that is that we have been the objects (I almost said victims) of the sales effort of the anti-friction bearing manufacturers and I congratulate them on the great measure of success they have attained. We should be very grateful to the various users that have pioneered in anti-friction bearings, as they have found out much about their mounting and the limitations of the earlier designs. Personally I think that the use of anti-friction bear-

*Electrical Division, SKF Industries, Inc., N. Y. C.

*United Engineering & Foundry Co.

†Gen. Engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

ings will be greatly extended and are a very valuable addition to the mechanical devices.

However, I wish to call your attention to the fact that in every case where unstinted praise has been accorded anti-friction bearings by users it has been where they have been applied to obsolete motors, such as the "K", "M" or other of the earlier types of motors, or to present types of motors that are equipped with bearings that are obviously improperly designed. My object in bringing this to your attention is to induce you to maintain an opened and inquiring mind on the subject of bearings; to induce you to study closely the designs of the various bearings that come under your observation; to induce you to discover for yourself why they are good, bad or indifferent; to induce you to maintain accurate records of bearing performance so that you may have a true and unbiased foundation on which to base your conclusions. Information of this nature is urgently needed and will be greatly appreciated by manufacturers of all classes of apparatus. Changes to existing lines of apparatus, and when considering new designs, information is desired that is based on facts; facts that leave no room for personal opinion or erroneous information that is based on experiences that are not comparable.

In conclusion, would say that in justice, the propaganda and experience of users of anti-friction bearings has had a very great influence on the design of modern bearings, both of the sleeve and anti-friction type, and have served to arouse interest in the question of lubrication and its effects on maintenance.

H. D. Else*: Saving on electric motor would rarely exceed 1½ per cent. The saving made is proportional to the power losses in equipment. On electric motor your power losses do not represent 2 per cent of your input. When you get into anti-friction bearing equipment the loss on the bearing represents 100 per cent of power output and it is a different situation. If you are looking for power saving you have to consider the bearing losses in the machine and take your quota; 60, 70, sometimes around 40 per cent, that will give you a rough way of estimating power saving.

O. S. Jeffries†: Being a representative of a firm manufacturing cranes, I would like to tell you what we have learned about roller bearings as applied to cranes. After applying roller bearings to automobiles, it was found necessary to build good roads to get the best results. For the roller bearing cranes, this also holds true; the track should be straight and level. When a crane having roller bearing bridge has been started the next thing to do is to stop it, this is done by means of electric and foot brakes, but by applying a friction brake to a free running load, it is difficult to keep same in repair. It has been found that a shunt solenoid brake which is across the line and which opens the brake when the main switch is put in and which closes when the main switch is pulled out, or when the power fails, this protects the crane on a failure of power, but is plugged at all other times. With the right resistance in the first two steps, this makes it easy electrically and mechanically without wearing on any parts. In speaking of the saving of power by anti-friction bearings when applied to a motor; this is multiplied many times when applied to a crane complete. In an open hearth where the power consumption was always higher than the rest of the plant, it was found that after running a hundred and fifty ton ladle crane equipped with anti-friction bearings throughout, that the power consumption had fallen noticeably below the rest of the plant. Then speaking of the anti-friction bearings as a safety factor. The fact that you can run these anti-friction bearings so long without renewing the lubrication is an important safety factor, permitting one to lubricate on Sunday or on shut down periods. Fifty per cent of the accidents occur from trying to lubricate while crane is in operation. We have found that the roller bearing has so greatly reduced the up-keep of the crane that it is the very biggest step in maintenance cost in a number of years.

R. B. Davenport*: About six years ago we started to experiment on our 12-A motors, and in cases where we used to have to change bearings once every six weeks we have had them run up to two and one-half years using roller bearings. I am strongly in favor of the anti-friction bearing on account of reliability of operation, repairs and in every way. We used to have a schedule made up for changing a motor every six weeks because we figured the bearings were gone; now we can forget them for a couple of years.

S. S. Wales†: How many 12-A's in service?

R. B. Davenport: About seventy.

S. J. Randall‡: As to ball or roller bearings from a shop standpoint, I really believe that you should give the roller bearing end play. When the armature is running the magnetic pull will center the armature itself, and be free from friction. If they do not have any end play on high speed they will heat up a great deal, more or less, and will give one trouble.

The Youngstown Sheet & Tube Company has changed a large number of armatures over to Rollway Bearings, changing about six to eight a week. We have changed over one hundred motors this year. The method of application which we decided upon in the shop is this—after the armature is in the motor, one should be able to push the armature back and forth about 3/16". I find by putting the bearings in hot water for a few minutes to expand the inner-race is a much better job than driving them on the shaft.

The time has come when you must pull most all roller or ball bearings off the shafts in order to do any work on the commutator. It is not very safe to put an armature on an angle with bearings. It seems to me that it is coming to this point, where there should be a standard bearing for a motor. All the new motors coming in are equipped with Rollway Bearings.

S. S. Wales: I will not attempt a technical discussion of ball or roller bearings, in the presence of so many experts and the very valuable papers to which we have listened this morning and those which we are to have this afternoon, but I will try

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†Service Dept., The Morgan Engineering Co., Alliance, Ohio.

*Supt., Elec. Dept., Carnegie Steel Co., New Castle, Pa.

†Chief Elec. Engr., Carnegie Steel Co., Pittsburgh, Pa.

‡Shop Foreman, Elec. Mach. Shop, Youngstown Sheet & Tube Co., Youngstown, Ohio.

to draw some conclusions from the trend of the times.

Roller or ball bearings, have demonstrated their advantages where ever power is of high value Their first extensive adoption was in the bicycle where the driving power was derived from human muscles, which naturally dictated the maximum conservation.

Their greatest field today is the automobile when the fact that all the fuel must be carried in a comparitively small tank and any increase in engine size, to overcome unnecessary friction required additional fuel, again calls for the highest bearing economy possible.

The adoptation of anti-friction being to mill motors is part of the sequence of economics, which has been under way for many years, due to the even increasing cost of fuel, beginning with the discarding of the wasteful hoisting engine for driving mill tables in favor of the more efficient electric motor.

Where fuel carries a low cost there is less need to conserve power, so we might not expect to find steel manufacturers, in a country so generously supplied with coal as the United States, as deeply interested in anti-friction bearings as some in Europe, where fuel is scarce and of poor quantity. With us the total power bill runs from $1 to $2 per ton of finished product, not including wire or thin sheets.

Therefore, we need not be surprised to find, as early as three years ago, an 11 inch merchant mill consisting of three stands, finishing ¼" to ½" Rds. and ½" to 3¼" wide flats, located in the large steel works of Witkowitz, Chech-Slovackia—an account of which will be found in the Iron Age. On a test covering 3053 tons or 27,000 liniar feet of finished material, representing over 15,000,000 revolutions of which over 9,000,000 were under load, no wear or damage to the bearing could be detected. The idle friction was reduced 69 per cent over the standard type of bearings, showing .325 Kw per bearing against 1.02 Kw. No comparative test under load is recorded.

In addition to the saving in power a claim is made for less change in section, therefore, less weight tolerance to be taken care of. It is also claimed that very little lubrication is required but that grease is forced into the bearings mainly to insure the exclusion of water and sinter.

From this mill the Witkowitz engineers, are willing to recommend anti-friction bearings for mills up to 17". S.K.F. bearings were used on this mill, and perhaps Mr Erickson, the representative of the S. K.F. Industries can tell us more about it.

The Timken Roller Bearing Company, has developed in this country a 16" merchant mill for rolling alloy steels, where the material is tough and size requirements are exacting which has been in operation for several months, about which I hope that Mr. Else, will tell us.

Another recent application of roller bearing has been to the four high mill for rolling thin steel strip, one manufacturer having sold 35 such stands within the last 18 months, also where it is important to maintain exact gauges.

From the above references and the constant increase in fuel cost we may predict that the future will see roller bearings applied to mills of much larger sizes than now considered, both in Europe and America, although considerations of the accurate gauge of product and reduced upkeep of bearings may have the more immediate influence here, than fuel cost.

J. S. Murray*: We have only a few installations of ball and roller bearings on motors at the Toronto Plant, and one of these installations on a 125 H.P. induction motor, 1750 RPM is a complete failure.

We are getting very good results from the improved sleeve bearings on our general purpose stationary motors without having to change the original stock of bearing sleeves or making any changes in the method of mounting, and I agree with Mr. McShane when he stated that one of the many changes that has been brought about from this bearing duscussion was the vastly improved sleeve bearing development.

We are contemplating the application of roller bearings on some mill type motors used on cranes and tables because improved sleeve bearings cannot be had for this type of motor. However, I believe that anti-friction bearings generally will be successful on electric motors, if properly designed, providing standard methods of mounting them are developed, which, of course, can be had by complete co-operation of the bearing manufacturers with motor builders and users.

J. R. Lewis†: We have built approximately 75 motors with anti-friction bearings in the past five or six years, (including some of our own motors, which users have changed over from sleeve to anti-friction bearings.) My company asked me to find out here today some things we would like to know. One of the questions I was asked to find out:

1. Whether there is going to be a demand for split roller bearing?

And on that same subject—

2. If there is going to be any demand for split shafts equipped with anti-friction bearings? That is a question we might get some light on

Another question I would like to bring up is—

3. Whether any of you have had any experience in the use of anti-friction bearings as to a good rule of where you stop with roller bearings and where you begin to change to ball bearings? In other words, around steel mills they have sort of adopted a scheme where they have been using roller bearings for heavy duty but up to a speed of a certain amount; whether that is 1000 or 1200 or 1500 revolutions we would like to know.

4. Another point: If we do use roller bearings on high speed motors, whether we have a way of telling that we are on the wrong end? We know some instances of motors 1200 to 1500 revolutions where they have been very noisy. Some mill fellows will tell you where you get a lot of noise you are bound to be on the wrong track. We had some motors not long ago, 75 H.P. variable speed, 500 to 1500 revolutions, very noisy, yet ran two solid days in test and could not get any sign or intimation of heating and yet we had this terrible noise. I would like to know if noise is an indication we are on the wrong track, or whether we have wrong application? (of say, using roller bearings.)

*Elec. Supt., Follansbee Bros., Toronto, Ohio.

†Crocker-Wheeler Elec. Mfg. Co., Pittsburgh, Pa.

5. Another thing: Whether anti-friction bearing people are prepared at this time to tell the motor manufacturers how much percentage of thrust the motors could stand on account of the use of bearing with helical gearing. It is important with steel mill motors that we be able to get roller bearings from the manufacturers of such to meet this heavy thrust that has come in and which we did not have before.

6. Another point is whether on general purpose motor you would put ball bearing in one end and roller bearing on the other end? Is that a better suggestion for a general purpose motor than putting, say, ball bearings at both ends?

7. Another point, possibly not necessary to discuss is: What kind of grease, what we should use and what we should recommend? I can say we have secured this information at this meeting in very good shape.

8. The next question is about the mounting. What Mr. McCutcheon says is very fine and am glad to take that information back with me, because that has been a difficult situation and we have all had trouble with mounting This is especially important owing to the fact we have had trouble in getting too close clearance on bearing on mounting.

I want to take back from this meeting a very good line of suggestions we can take up. In closing, wish to say here, because it was our customers in this district, backed up by Pittsburgh, who were the ones who forced us into the situation whereby we are now committed to the line of motors we are making. We are going to recommend or push exclusively the use of anti-friction bearing, but if anybody wants the sleeve bearing they can have it.

M. W. Cobbledick: I think Mr. Lewis' remarks are very good, but I do not believe we had better start to discuss them today, for the hour is very late. So I think Mr. Lewis will get the information he desires from different meetings in the future.

The Maintenance of Locomotive and Rolling Equipment of the Reading Company

By I. A. SEIDERS*

Mr. Chairman and Gentlemen of the Association of Iron and Steel Electrical Engineers:

When your President and others asked me to present a paper for this meeting, coming from a motive power man of a railroad, I realized that I had some task before me, because I knew that what was wanted was a paper that would be interesting, and in my endeavor to present such a paper I hope I have made it so.

The Motive Power Department of the Reading Co., of which I have the honor to be the head, comprises the following in Reading:

2,800 men at Reading Locomotive Shop, including our office force.

1,000 men at Reading Car Shop, and 300 men at Reading Enginehouse, and in addition, 5,200 men at outlying points, along our 3,800 miles of trackage, between Newberry Junction which is at Williamsport, Port Reading, which is our New York harbor terminal for coal delivery, Harrisburg, Philadelphia and seashore points, where we have 10 car shops and 21 enginehouses.

The Reading Co. has 1,100 locomotives, 43,000 freight cars, 1,000 passenger cars, two gas rail cars, 1 oil-electric locomotive, 1 gas-electric car, and 3 gas-electric cars to be used with trailers now building at the Brill Co. plant, Philadelphia, and which will shortly be ready for service.

Our annual maintenance cost per locomotive is $5,800, per passenger car $1,000, and per freight car $150.00. Totaling this for a year amounts to the following expenditure:

$6,500,000 for locomotives.
$1,000,000 for passenger cars.
$6,300,000 for freight cars, or about
$14,000,000 per year for all equipment.

*Supt. M. P. and R. E., The Reading Co., Reading, Pa.

Our Company has $108,000,000 invested in rolling equipment, and over $16,000,000 in shops and power plants, including buildings and machinery, or a total investment of $124,000,000 in these items.

Our modern passenger locomotive, known as a Pacific 4-6-2 type, costs approximately $58,000 each.

I. A. SEIDERS

Our modern steel 70-ton coal car costs $2,400, and our most modern passenger car costs $23,500.

Our locomotives consume $7,000,000 worth of fuel in a year.

We also have at Reading Shops, 30,000 patterns valued at $350,000.

You will, therefore, readily see the important part that the motive power or maintenance department

plays on the railroad in keeping its power and rolling equipment in the best of condition, ready and available to move the business that is turned over to it.

Our locomotives make a total yearly mileage of 27,000,000 miles, freight cars 350,000,000 miles, and passenger cars 37,000,000 miles.

Repairing of Locomotives at Reading Locomotive Shop.

When a locomotive is in need of a general overhauling it is brought to our Reading Locomotive Shop for this wook.

The repairs are determined by class and are divided as follows:

Class No. 1 Repairs:	New boiler or new back end. Tires turned or new. General repairs to machinery and tender.
Class No. 2 Repairs:	New firebox or one or more shell courses or roof sheet. Flues, new or reset. Tires turned or new. General repairs to machinery and tender.
Class No. 3 Repairs:	Flues, all new or reset. Necessary repairs to firebox and boiler. Tires, turned or new. General repairs to machinery and tender.
Class No. 4 Repairs:	Flues, part or full set. Light repairs to boiler or firebox. Tires, turned or new. Necessary repairs to machinery and tender.
Class No. 5 Repairs:	Tires, turned or new. Necessary repairs to boiler, machinery and tender, including one or more pairs of driving wheel bearings refitted.

General repairs to machinery will include driving wheels removed, tires turned or changed, journals turned, if necessary, and all driving boxes and rods overhauled, and bearings refitted and other repairs necessary for a full term of service.

A full term of service is considered 12 months.

Locomotives receiving Class 1, 2 or 3 repairs must be put in condition to perform a full term of service in the district and class of service in which they are used.

Procedure in Preparing the Locomotive for Repairs

The locomotive is brought from the roundhouse dead, that is, with its fire out and water drained. It is put on a straight track in the Shop and lifted bodily with a 150-ton capacity crane and set on the transverse tracks in the erecting shop.

The boiler is lifted off, if necessary, and sent to the boiler shop by crane service and set down ready for repairs. It might require a new front course, perhaps a back head or new flue sheet, or other necessary boiler work, making it in some cases nearly equal to a new boiler.

The driving wheels are sent to the boiling vat to have the dirt and grease removed, and are then put on the oil heater to be heafed up to sufficient density for the removal of tires, if necessary. If they only require re-turning, they are sent to the wheel or tire cutting machine to be re-turned.

The driving boxes are sent to the box gang, the rods to the rod gang, the injectors to the injector gang, and so on, to have the necessary repairs or renewals made, and are then delivered to the Erecting Gang which is assigned to erect the locomotive and it is again made serviceable.

This process of repairs requires at times three, four, five or six weeks, depending, of course, on the amount of repairs required to bring the engine up to good condition, as I outlined in the class of repairs the locomotive receives.

You will or have noticed in your inspection of our shop at Reading the manner in which the shops are laid out.

The Erecting Shop tracks are divided into east and west bays, and in and along the center aisle are various machines that perform the necessary work in helping to turn out the locomotive.

In addition, we have the upper machine shop, adjacent to the above, where the tire or wheel machines, cylinder boring machine, driving box department and air brake department are located, together with a drop table and Whiting hoist that is used to raise up our Mallet type engines, as they are too large an engine for the track space in our transverse shop, or to drop the driving wheels for re-turning or renewing of boxes, etc.

South of the Erecting Shop is our Boiler Shop and the Tender Repair Shop, where new boilers are built or old ones repaired, fireboxes applied or repaired, and all other boiler work necessary for the proper functioning of the locomotive.

Close to the Main Erecting Shop is our Blacksmith Shop, where all forgings are made, frame sections, levers, rods, etc., formed.

Near this building is the Foundry, where all our cast iron and brass castings are made.

We manufacture all our grate bars, cylinders, end sills and all other cast iron parts used on locomotives and cars, and supply such other castings that are used on the entire railroad. We also manufacture quite a number of our own journal bearings, and many other miscellaneous castings.

The shops are equipped with five 10-ton cranes in the Lathe Gang; one 35-ton, one 10-ten and two 7½-ton cranes in the New Machine Shop, and two 150-ton, two 35-ton and two 10-ton cranes in the Erecting Shop; one 35-ton and one 10-ton crane in the Boiler Shop; one 10-ton crane in the Smith Shop; one 10-ton crane in the Foundry, and one 10-ton Gantry crane in the Yard.

With the 2,700 men we have at Reading Locomotive Shop we are able to turn out 15 to 18 classified repaired locomotives per week.

It might be of interest to tell you some of the methods of repairing the locomotives. For instance, the welding together of materials, such as back head sheets, flue sheets, frames, cylinders, etc., by the process of electric and oxy-acetylene methods.

Electric Welding

There are certain parts of the locomotive that require electric-arc welding in preference to the oxy-acetylene method. All boiler work, such as piecing

out flue sheets and welding same in, side and roof sheets of fireboxes, back head sheets, etc, are electric-arc welded. You must realize that a modern locomotive carries a boiler pressure of 200 lbs. and over, and the stresses in the various sheets are high, and especially so where due to the extreme heat considerable expansion takes place. This is the underlying reason why the electric-arc welding process is used on locomotive boilers.

The current required for carbon arc welding is usually between 300 and 400 amperes at approximately 50 volts.

The power consumed in the metallic arc will depend on the nature and mass of the metal forming the electrodes. For ordinary metallic arc welding 50 to 200 amperes per operator at from 15 to 35 volts measured at the arc will be required.

The design and control of the machines for carbon arc and metallic arc welding are practically the same.

Oxy-Acetylene Method of Welding

The use of acetylene in autogenous welding has rapidly extended since its first introduction. This is due to the peculiar conditions resulting from the burning of acetylene in a stream of oxygen.

Acetylene is a chemical combination of carbon and hydrogen, and the burning, i. e., its combination with oxygen, takes place in two phases, with a well defined zone formed of the first phase, that is carbon monoxide and hydrogen.

We have our own generating plant where the acetylene is made and distributed through pipe lines to various stations in the shop, together with oxygen manifolds, and we have quite a number of welders working constantly in the reclamation of various materials.

We reclaim locomotive cylinders that have been broken, all kinds and grades of castings, such as body bolsters, truck bolsters, end sill filler castings, center plates and other castings too numerous to mention, also steel plate sections, and we save a considerable amount of money for our Company by the use of this reclamation process.

I have given you up to now a brief outline of what we do in connection with the repairing locomotives. I have not given you anything as to the operation of a locomotive and how we are governed in connection with this operation by the Interstate Commerce Rules.

First, we cannot operate a locomotive without first filing with the Bureau of Locomotives of the Interstate Commerce Commission a specification sheet describing the locomotive, the boiler, steam capacity, the type and size of safety valves, the factor of safety and stress figures of the boiler courses.

Then we are compelled by the rules to have a daily inspection made of each locomotive.

We cannot operate a locomotive without being in violation of the rules, if:

The tire wear is below a certain prescribed limit.

If there are steam leaks that might cause obstruction of the engineman's view.

If the side rod and main rod brasses are below a certain restriction.

If the crossheads have too much later or vertical motion.

If the lateral motion on two or more drivers exceeds ¾".

If the locomotive is operated without a hydrostatic or annual test card, or monthly boiler inspection card not in place in the cab showing that the various items of inspection have been taken care of, and forms signed and sworn to, and numerous other items that I will not take the time to mention.

The railroads are compelled by law to install electric headlights on all locomotives, and where a locomotive is assigned to road service the headlight must be of sufficient density to distinguish an object the size of a man standing upright on a clear night at 800 feet. Therefore, it is necessary to install a generator having a capacity of 32 volts to come within this law.

Automatic Train Control

Another important ruling made by the Interstate Commerce Commission, effecting 49 Class 1 railroads, of which this Company is one, was to require the installation of a train control device that would stop the train if for any reason the engineman was not alert and passed a caution or danger signal without first acknowledging it or reducing the speed of his train. We have such a device installed on 53 locomotives operating on our Atlantic City Railroad from Camden to Atlantic City.

This device is known as a three-speed continuous automatic train control. It operates electric-pneumatically in conjunction with roadside signals.

If the train exceeds a certain fixed high speed limit an automatic brake application will ensue, and the train will stop if the engineman is not alert.

If the train passes a caution signal faster than a certain fixed speed, and the engineman is not alert and does not reduce the speed of his train, the train will stop.

If the engineman does not acknowledge and reduce his speed approaching a danger signal, at a predetermined distance back of this signal the train will stop.

This device consists of a separate electrical generator, pick up coils or current receivers, applied to the locomotive back of pilot and at the end of the tender, a speed governor, where a drive shaft is connected to it from the wheels of engine truck, and a pneumatic valve that works in synchronism with the governor to apply the brakes, amplifiers and electrical relays, which amplify the current picked up from the rails.

If any of you ride from Philadelphia to Atlantic City over our road you can see this device, as all trains operating on this line are in the train control zone.

I thought a brief description would not go amiss, and I will now go back to our Reading Shop.

Freight and Passenger Car Repairs

As I stated earlier in this paper, we have 43,000 freight cars and 1,000 passenger cars.

In one year we repair 330,000 freight cars, 135,000 of which are foreign cars, that is, cars belonging to other railroads, and by agreement in connection with the American Railroad Association we repair the other fellow's cars as well as our own, whenever the condition is such that comes within the rules.

The above number of cars repaired is not confined to Reading, but to all our outlying shops and inspection points.

We repair at Reading an average per year of 5,000 light repair freight cars, and 9,800 heavy repair freight cars. Also 202 light repair passenger cars, and 400 heavy repair passenger cars.

I will now give you a description of the power plant we have at Reading Shop and how we join with the Metropolitan Edison Co. the current which we purchase from them.

Power Plant

Our power plant was built in 1901 and additions made thereto in 1905, 1917 and 1926.

The equipment consists of fourteen 250 horse power Wickes vertical water tube boilers equipped with Roney stokers. We have to modify these stokers ourselves in order to procure higher efficiency with the use of anthracite coal.

These boilers supply steam for the generators, air compressors, steam hammers and some direct heating and testing throughout the shop.

Engine Room Equipment

This equipment consists of two 800 k. w. direct current generators, three 400 k. w. alternating current generators, and two 50 k. w. direct current exciters.

In addition, there are installed one steam driven air compressor, and two 3,720 cu. ft. motor driven air compressors.

The engines are of the reciprocating type, and were installed prior to 1906.

The power generated in this plant is used throughout the Locomotive Shop, Machine Shop, Boiler Shop, Foundry, Carpenter Shop, Wheel Shop and Reading Enginehouse. We furnish the lighting for Reading Passenger Station, and the Transportation Yards throughout the Reading District.

This plant and connections furnishes power for buildings and grounds covering approximately 50 acres.

At this time there is approximately 750,000 kilowatt hours of power consumed per month generated at the plant and approximately 100,000 kilowatt hours of power purchased from the Metropolitan Edison Co. The purchased power, however, will be increased as we progress in the new car shop.

Electrical Work at the New Reading Car Repair Shop

Current for operation of the electrical facilities in the new car repair shop is supplied by the Metropolitan Edison Co.

Two incoming connections supply power at three phase, 60 cycles, 13,800 volts.

These are joined to a common bus at an outdoor sub-station through two 400 ampere, 15,000 volt, three pole, single throw, electrically operated oil circuit breakers.

Disconnecting switches are provided on both sides of the breakers, so that switches can be entirely disconnected from the lines in case it is necessary to work on them.

The main switches are remote controlled, being operated from the switchboard in the power house about 600 feet away. An underground cable circuit supplying 250 volts direct current is used for this operation.

In order to distribute the current supplied by the Metropolitan Edison Co., the Reading Co. has provided an outdoor sub-station, in which are located three General Electric Co. transformers of 1,000 K. V. A. capacity each and have a stepdown ratio of 6 to 1, or from 13,800 volts to 2,300 volts.

The transformers are protected against lightning by Westinghouse Type SV auto valve lightning arresters.

The steel structure in the sub-station was fabricated by the Electric Power Equipment Corporation, and was erected by Woodfield-Thompson Co.

The main sub-station is 50 ft. 3 in. x 32 ft. x 30 ft. high.

Power is taken from the sub-station to the power house through an underground fiber conduit duct line. Manholes are provided at frequent intervals for installing and inspecting underground lines.

A total of 25 ducts are provided, of which 8 are spares, and vary in size from 3 to 5 inches in diameter.

Power is carried to the switchboard in the power house by means of four 3-conductor, 350,000 circular mill, varnished cambric, lead covered cables.

This installation has been so designed that total load can be carried on two of the four 3-conductor cables, thus allowing a safety factor in case of cable trouble.

In the power house a new switchboard has been installed consisting of ten alternating current panels, three additional direct current panels, and a tie-in switch panel to transfer power from Reading Co. 440 volt, two phase, 60 cycle bus to the new alternating current bus.

The present generation in the Reading power plant is 440 volts, two phase, 60 cycles, and power furnished from the Metropolitan Edison Co. has also previously been transformed through Scott connected transformers to 440 volts, two phase, 60 cycles.

Our new installation has been made on the basis of 2,300 volts, three phase, 60 cycles, as a method of distribution, and new switchboard has been designed on this basis.

The 2,300 volt, three phase distribution was decided on as a better system of distribution than 440 volts, as it eliminated a number of transformers required for transformation and distribution to various points.

Under the arrangement as installed, distribution is made from new switchboard to take care of new equipment installed in the power plant.

In order to take care of additional air requirements, two 650 horse power, three phase, 2,300 volt, Westinghouse synchronous motors have been installed to operate two Chicago Pneumatic Tool Co. Compressors of 3,750 cu. ft. per minute capacity each.

Provision is also made to take care of requirements for a 500 k. w. synchronous motor-generator set with 750 horse power motor rated at 2,300 volts, three phase, 60 cycles, to be installed in the power house to take care of direct current requirements, and to replace, as far as possible, direct current furnished from the present two 800 k. w. direct current machines.

Panels are provided on switchboard to control circuit feeding present power requirements in installations in our old shops of approximately 800 K. V. A. at 2,300 volts, and also to take care of power and lighting requirements in the new freight car repair shop.

This distribution is effected by taking underground cable from power house, through duct line previously referred to, to two outdoor distribution sub-stations.

These outdoor sub-stations are designated as the North Reading Sub-station and the New Car Repair Shop Sub-station.

In the North Reading Sub-station are located two banks of two 150 K. V. A. transformers each, to step up power delivered from power house at 440 volts to 2,300 volts for distribution to enginehouse and pumping station on one circuit, and to coaling station and ash crane on second circuit.

There are also located at this sub-station two 50 K. V. A. single phase transformers for lighting the enginehouse, and two 400 K. V. A. Scott connected transformers provided to take care of service during the possible interruption of Metropolitan Edison Company power.

If these latter transformers are used, power will be furnished from Reading Locomotive Shop at two phase, 440 volts, and transformed to 2,300 volts, three phase, for distribution from new switchboard installed, or vice versa, 2,300 volts, three phase, Metropolitan Edison Co. service can be changed to 440 volts, two phase, for our two phase requirements.

In the New Car Repair Shop Sub-station there is a bank of six transformers.

The lighting bank consists of three 100 K. V. A. single phase transformers, with step-down ratio of 2,300 to 220-110 volts.

The power bank consists of three 200 K. V. A. single phase transformers, with step-down ratio of 2,300 to 440 volts.

Power is brought into the car shop through underground fibre ducts.

A dead front switchboard has been provided, which consists of six slate panels, on which are mounted three main alternating current lighting oil switches, one main alternating current power oil switch, seventeen safety switches for the various lighting circuits, six safety switches for the power circuits, and six U-Re-Lite circuit breakers for controlling direct current requirements throughout the car shop.

The switchboard has been laid out with the idea in mind that there should be no live parts on the front of the board, and the back of the board will be enclosed with transite panels, so as to totally enclose the live parts of the board, and to protect this installation from dust accumulations from woodworking mill in which it is installed.

From the panel board the various lighting circuits are taken to the various distribution points throughout the shop.

There are located in the main shop six 12-circuit distribution panels for controlling the various circuits.

There is also a total of six distribution panels in the wood mill, bench room, lumber storage room, machine shop and smith shop.

In the main shop there is a total of 132—750-watt lamps and 78—500-watt lamps.

In the remainder of the shop there are 176—500-watt lamps, and 23—300-watt lamps, or a total of 409 fixtures.

The Wheeler "RLM" dome porcelain steel enameled reflector has been used throughout this installation.

In addition to the overhead illumination, individual machine lighting was provided where necessary for close work, a Faries flexible lighting unit being used.

Approximately 40 welding receptacles are installed at various locations throughout the shop.

Current for welding is supplied from a 500 ampere motor-generator set installed in the shop.

There are also installed 110 portable plug receptacles for extension cords.

Crouse-Hinds fixtures are used in both installations.

A watchman's circuit is also provided for overhead illumination at night, so that it is not necessary to place any number of lights in service after working hours.

Direct current is provided in the shop for crane operation, and for a few direct current motors on machines moved from the old shop.

The majority of the direct current, however, is used for operation of the four 25-ton and two 50-ton Niles cranes installed in the shop.

There are approximately 50 motors now installed on the various machines located in the shop, which are fed from five overhead circuits, feeding current at 440 volts, three phase, to the points where needed.

Motors are controlled by Westinghouse Across-the-Line starters up to five horsepower, and by Westinghouse Type AF full automatic starting compensators for installations over five horsepower.

The majority of the motors are Westinghouse sealed sleeve bearing motors.

As an idea of the magnitude of this installation, it might be noted that there were used in connection with the electrical installation, approximately 135,080 feet of wire, 23,760 feet of cable, 39,600 feet of steel conduit, and 17,160 feet of fibre conduit.

The entire installation was designed and supervised by my department.

Reading Enginehouse.

We have at this point a modern roundhouse, which is situated close to our Reading Shops, where we handle the road and switching power assigned to the Reading District.

We handle about 70 engines each 24 hours, and the average man hours per locomotive dispatched is 30½ hours.

The roundhouse proper was completed during the war, but just recently we finished a new 1000-ton coaling station, inspection pits and ash pit facilities.

We have 300 men assigned to this point to take care of the handling of locomotives.

We have 27 tracks within the circle, and can house on these tracks about 45 engines.

We have a 100 feet balanced type turntable, electrically operated. This table is used to turn the locomotive to run in the tracks designated, head on,

and when dispatched to turn it head on in the direction in which it is to go.

All locomotives turned out of Reading Shops go to this house, first to have the tender connected, and then fired up, tested for leaks, and run or broken in by a special crew assigned to this work before engine goes into service.

The men designated to handle these locomotives in preparing them for service after being discharged from the Shop are regularly assigned to these duties. This is called our inspection force, and the men are experts in their line of work.

While we do not, as a rule, make very heavy running or classified repairs to the locomotives at this point, we do, however, make such repairs to keep engines efficient for the service to which assigned.

Coaling Station at Reading Enginehouse.

The purpose of this coal handling plant is to dump coal, bituminous and anthracite, into two receiving hoppers, one located under each of two parrallel receiving tracks at the east end of the plant.

Each receiving hopper is equipped with two 2½-ton Standard Schraeder Measuring Feeders, there being four feeders in all, and each feeder being calibrated so as to graduate the amount of coal delivered.

The feeders are so calibrated that any mixture of the two kinds of coal from 10 per cent anthracite and 90 per cent bituminous to 50 per cent anthracite and 50 per cent bituminous may be delivered.

Each bucket dumps the mixed coal into a steel chute at the top of the structure. From this chute coal is fed through a coal crusher to overhead storage bins, or the mixed coal will be by-passed around the crusher and delivered to the overhead storage bins.

There are 9 coal pockets, 7 have storage capacity of 125 tons each, one of 75 tons and one of 50 tons, making a total for the 9 pockets of 1000 tons.

This 1000 ton total storage is divided by concrete partitions, so as to provide smaller bins as above enumerated.

From the level of the tracks up to and including the peak of roof the construction is of steel reinforced solid poured concrete, reinforcing being made with deformed bars and contains no metal exposed to the action of the fumes or elements.

The mechanical parts of the coal handling plant consist of the following:

Two Roberts and Schaefer Co. cast iron automatic reversible hoists with 36" diameter drums and all steel cut gears for direct connection to two 40 horse power, 440 volts, 2 phase, 60 cycle, General Electric Type Mqc 40-degree motors with solenoid brake to prevent dropping the buckets in case current is accidentally cut off.

Two oil circuit breakers with overload and under voltage protection.

Two Roberts and Schaefer Co. automatic electric controllers, manufactured by Cutler-Hammer Manufacturing Co. This controller permits the continuous ascent and descent of the elevating bucket without an attendant, as the operation of elevating coal is started by a D-13 electric push button control, and likewise stopped by pushing this button.

After the machinery is in operation, the operator of the coaling plant devotes his time to dumping cars over the track hopper while the elevator process is going on, or attending to the sand handling plant.

Each hoist has its drum shaft geared direct to a Cutler-Hammer traveling cam enclosed limit switch, which brings the motor to rest at the definite bucket discharge point at the top of the tower and at the filling point in the pit.

The reverse operation is accomplished by Cutler-Hammer automatic control push starting and stopping station.

Two 2½-ton capacity Standard Patent Elevating Buckets, manufactured with 6" double flanged rollers on the bucket aprons, which travel on continuous 30 lb. steel rails from the bottom of pit to the bucket discharge point.

Coal Crushers.

This proposition includes two 30" x 30" Jeffery Single Roll Coal Crushers.

One underneath each chute and each capable of crushing 75 tons per hour of bituminous run of mine coal to 4" cubes or to chestnut size in one operation.

Each crusher is driven by direct connected 30 horse power, 40 degree, 900 R. P. M., slip ring, General Electric Type Mq motor.

Mixing Mechanism.

The receiving hoppers are equipped with Roberts and Schaefer Co. patented adjustable calibrated measuring feeders, permitting a definite quantity of anthracite coal to enter one feeder, and a definite quantity of bituminous coal to enter the opposite feeder, each for delivery to the same bucket, so as to secure a thorough pre-determined mixture of the two grades of coal in either or both of the two elevating buckets.

Each mixing device will have an indicator to show position of deflector for certain standard mixtures.

Sand Handling Plant.

This plant is built in conjunction with the coaling plant and has a capacity of 250 tons, a dry sand storage capacity of 125 tons, and equipped with three No. 3 Beamer Patent Rectangular Steam Sand Dryers, having a combined drying capacity of 24 tons in 24 hours.

This plant was designed and built by Roberts and Schaefer Co. and I felt it would be interesting to you to know some of the fundamentals of it, as we think it is a remarkable and up-to-the-minute coaling station.

After the conclusion of this paper and its probable discussion, our Mechanical Engineer, Mr. Charles A. Bingaman, will give you a description and show you on slides our modern new freight and passenger car repair shops that are almost ready for occupancy—in fact, we are now repairing some of our steel freight cars in this shop. He will outline in detail the construction of the shops, together with the facilities we have or will have to take care of the repairing of these cars.

DISCUSSION

F. O. Schnure*: We have had a very interesting description of the repair shops which keep the

*Elec. Supt., Sparrows Point Plant, Bethlehem Steel Co., Sparrows Point, Md.

Reading system going, and however interesting it has been, it would not be complete unless we have a discussion of the pertinent features.

Some of the boys who I am better acquainted with, and who are associated directly with the Philadelphia Section, have to give an account to their wives for the time they spend away from home after 10 o'clock. I do not know how you gentlemen in Reading are fixed, but we will endeavor to get this meeting over by that time.

I would like to call for discussion. We would like to have the speakers come to the front who desire to ask question for two reasons: First, so that they can be heard through the microphone; and second, so that our stenographer can get their discussion. I am not acquainted with the railroad men in the audience, but we would like to have them come forward first. As we do not seem to have any railroad men who wish to discuss this paper, we have with us Mr. Pauly, of the power and industrial department of the General Electric Company, at Schenectady, and we will ask him to give us a few words in respect to railroads, particularly the phase relating to electrification.

K. A. Pauly*: I am afraid that I shall have to disappoint Mr. Schnure, for I think there is nothing I know less about than I do about railroads and railroading; in fact, one of the reasons I came down here today was to be initiated into railroad work. I have enjoyed very much the trip through the shops and have learned a great deal as a result of the afternoon's visit to Reading.

Mr. Wales mentioned this evening his twenty-five years affiliation with the Association. My memory carries me back to one of the first meetings of this Association which I attended; it was held in a small room in one of the hotels in Philadelphia and was only attended by a mere handful of steel mill men. At that time, the manufacturers, who were called upon to discuss their designs, were admitted to the meeting by themselves; that is, without competitors present. Obviously, the first manufacturer to obtain a hearing far exceeded his allotted time so that those who came later on the list had little or no opportunity to present their case. At this particular meeting, I well remember sitting outside in a little room, what seemed to be hours, before I was given an opportunity to present what little I had to say, but how different things now are. This was the beginning of an aggresive association made up of active men which, I believe, stands alone when considered from the real interest which they take in the work which they are trying to accomplish. I have many times stated that I believe the Association of Iron and Steel Electrical Engineers to be the livest group of engineers who get together in convention. I do believe, however, that they have stuck a little too close to the field of their daily work and I am especially pleased today to find that the Association is interesting itself in things out of the daily grind.

I am very much in sympathy with this sort of thing and believe that more meetings, such as this, can be held to very great advantage. The Association can well afford to call on speakers who are specialists in entirely different fields, thereby creating an interest on the part of members in other fields of activity, which must have a broadening effect upon them, and thereby be a real help to them in doing their regular work. If it does nothing more, it will make us feel better and enjoy the work we have to do because of the variety which it introduces.

I did not come here prepared to say anything and I am going to close with an apology to our railroad friends because, in spite of the fact that Schenectady is the headquarters of the American Locomotive Company, I have never before made an inspection trip through a locomotive plant. Perhaps it is only natural that I should go away from home to do this, but, whether or not this is the case, I have thoroughly enjoyed the afternoon and evening which I spent in Reading.

A. J. Standing*: I think we are greately indebted to the Reading Railroad and their representatives in Reading for the treatment we have had today. It has been a very interesting trip, and Mr. Seiders' paper has likewise been of the greatest interest. It is a good thing for those of us in the steel industry to see how some one else is doing a similar job. The care and precision with which repairs are made on locomotives to travel over the Reading Railroad has led me to feel that if I was reasonably sure they were running on Bethlehem steel rails I could cancel my accident insurance.

There are a number of interesting points brought up. The paper is very complete; and a complete paper does not leave a great deal to be said. However, there are two or three things emphasized in the paper which I want to touch upon.

The first point was that of carbon metallic arc welding on boiler plates and the explanation given that it was used in view of the high pressure maintained in those boilers. In other words, that gives a very clean bill of health to electric welding, which is a subject very close to our hearts, for electric welding has entered the field of structural steel work. It is somewhat akin to the nature of the work called upon in our structural operations.

Another feature of interest in this paper was the use of a so-called watchman's system of night lighting. That is a factor which is interesting in steel plants. In the plant that I am connected with in Bethlehem we have one system of lighting throughout the entire plant. The result is, unless departments are idle they are pretty generally illuminated. Of course this applies to continuous operation in steel works; it probably does not exist in the locomotive shops. We are operating twenty-four hours a day, which necessitates more light than is necessary in locomotive shops. However, there are a number of idle buildings, and in making trips through the plant at night we find considerable over-illumination. This plan of watchman's lighting has a good deal of value in it.

The physical condition of the plant was interesting. We all feel that a plant that is as clean and orderly as the plant we saw today is as a rule an efficiently operated plant.

Coming down to the subject of maintenance. The maintenance problems in the steel plant, railroad or any other industry, are more or less akin, and

*Engr., Industrial Dept., General Elec. Co., Schenectady, N. Y.

*Supt. of Elec. Dept., Saucon Plant, Bethlehem Steel Co. Bethlehem, Pa.

the fact you can repair a unit has long since ceased to be phenomenal. We are supposed to repair anything and everything, and do it as quickly as possible. But what we are also supposed to do is to maintain repair equipment at the lowest possible cost. No problem receives more attention than the problem of reducing the cost of maintenance. The price of our product is fixed. I some times feel that our management take rather an unusual dig at the maintenance end of it, with the result that when we are running along nicely without any delays the tendency is to feel we have too many men in our maintenance gang, and if they run into delays they feel we do not have enough men to do the work.

In view of the tremendous amount of equipment which Mr. Seiders has shown us today, it must require a remarkable system to keep track of costs and keep the equipment ready for operation.

I wish to express our gratitude to the Reading Company for their courtesy today.

Foundry Electrifications

By PHELAN McSHANE*

ONE who spends his time in close contact with an industry scarcely realizes the changes in practice and methods that have taken place about him; so gradual (and yet so quickly) do these changes take place that one seems to accept the changed conditions as though they always existed. It can be said without fear of contradiction that electrification is progressing as rapidly in the foundry industry, as fast if not faster than in any other. While a little slow in getting started it was not due to any tendency to be slow to adopt new and better methods, but owing to the conditions that surrounded the product itself. The production of a large variety of castings requiring continual changing in the type of patterns, cores and sand was not a situation that was well suited to the most favorable working conditions, nor the use, of what is now considered modern equipment. Quantity production has now changed all this and made possible the rapid strides that are taking place.

Perhaps the most marked difference in methods is to be noted in the means used to handle and condition sand. The shoveling of sand into the flask has been superseded by the flask filler, which not only reduces labor but completes the job quickly. The contrast between the shovel and the push button is one that is appreciated by the fellow that formerly used the shovel.

In many cases the sand slinger has superseded entirely other methods of ramming and has the distinct advantage of producing a uniformly rammed mold and that at a cost that places this device in a class by itself. These machines may be secured in several forms, that is stationary, portable and locomotive types. Either direct or alternating current motors may be used. The motors being controlled by push button located on the ramming head. The sand slinger not only rams the sand, but also elevates, cuts and screens it.

Where the shape of the pattern and other conditions make jolting of the flask desirable, the roll over jolt machine is available. The pattern is bolted directly to the roll over table and the flask placed around it. The flask is attached to the table by means of suitable clamping. Sand is then filled into the flask, see figure 2, after which it is jolted. The excess sand is leveled off and the top of the flask is covered and the cover clamped in place. The flask is then elevated and rolled over, see figure 3 and 4. A motor driven runout car is rolled under the flask and when in place the flask is lowered on it, see figure 5. The clamps that attach the flask to the table are removed and the pattern is drawn from the sand. See figure 6. After the pattern is clear of the mold the runout car conveys the completed mold away from the machine. The pattern is then

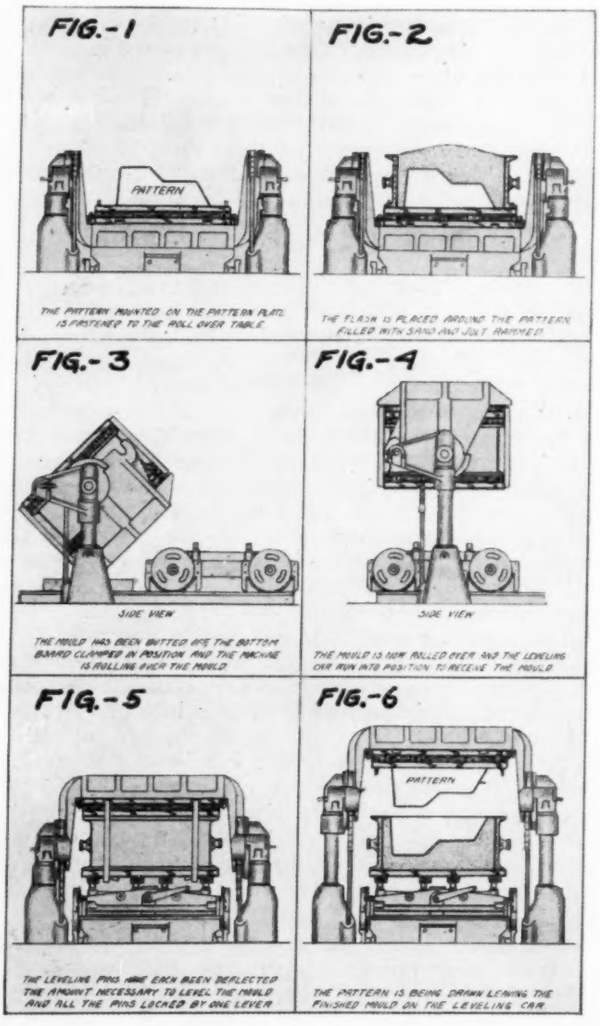
FIG.-1
PATTERN
THE PATTERN MOUNTED ON THE PATTERN PLATE IS FASTENED TO THE ROLL OVER TABLE
FIG.-2
THE FLASK IS PLACED AROUND THE PATTERN FILLED WITH SAND AND JOLT RAMMED
FIG.-3
SIDE VIEW
THE MOULD HAS BEEN JOLTED OFF THE BOTTOM BOARD CLAMPED IN POSITION AND THE MACHINE IS ROLLING OVER THE MOULD
FIG.-4
SIDE VIEW
THE MOULD IS NOW ROLLED OVER AND THE LEVELING CAR RUN INTO POSITION TO RECEIVE THE MOULD
FIG.-5
THE LEVELING PINS HAVE EACH BEEN DEFLECTED THE AMOUNT NECESSARY TO LEVEL THE MOULD AND ALL THE PINS LOCKED BY ONE LEVER
FIG.-6
PATTERN
THE PATTERN IS BEING DRAWN LEAVING THE FINISHED MOULD ON THE LEVELING CAR

*General Engineer, Westinghouse Elec. & Mfg. Co.

returned to its original position as shown in figure 1 and the process repeated.

All of the operations, with the exception of that of jolting, are accomplished electrically. The complete cycle of operation is under the control of a single operator and the various functions of the machine are accomplished in much less time than is required to explain it, and perhaps with much less effort. Either direct or alternating current motors are used with either manual or automatic magnetic controllers. As every operation of this machine is repeated over and over again with absolute uniformity, it is only reasonable to suppose that the production of uniform molds will result. This uniform action, coupled with scientific sand conditioning and control, has resulted in an efficiency of 85 per cent in a foundry making aluminum castings.

Perhaps the most spectacular advance in the foundry industry and one that has attracted wide public attention, is that known as the centrifugal pipe casting process. Attention has been directed toward it, not only due to its great merit, but also due to the action of the stock of the company owning the patents on the New York stock exchange. To cast pipe by this process a definite amount of molten iron is placed in a ladle, which is tilted at a uniform rate, pouring the metal into a self supporting runner that is slightly longer than the pipe to be cast. A water cooled steel tubular mold, which moves on slightly inclined slides or ways, is drawn over the runner and rotated slowly. A baked sand mold is located in the lower end of the tubular steel mold to form the bell. When sufficient metal has been deposited to form the bell the speed of rotation is increased and the mold is moved down the ways at a definite rate. Due to the fact that the end of the runner is curved toward the sides of the rotating mold, the metal is deposited in a ribbon like spiral. The metal contacting with the chilled mold solidifies almost instantly, producing a pipe with a glass hard surface. The pipe is withdrawn from the mold by inserting in it an expanding tongs and moving the mold up a ways. After inserting the mold to form the bell the machine is again in readiness for the next operation. The pipe is then annealed in a continuous annealing furnace, cleaned, dipped in asphalt paint and tested. Pipes from 4 to 12 inch inside diameter are produced. Forty pipe per hour is the average production of one of these casting machines. It is easy to imagine the important part played by electricity in this process. When watching a battery of these machines in action one wonders where all the pipe goes.

Application of Anti-Friction Bearings to Roll Necks of Steel Mills

By E. C. GAINSBORG*

AT A meeting of Iron and Steel Electrical Engineers held recently at Youngstown interest was manifested by some of the members in the application of anti-friction bearings to roll necks of steel mills. This subject is one which the manufacturers of ball and roller bearings have given a great deal of thought. Due to the heavy loads to be carried, there are a number of serious problems which practically exclude the use of conventional types of anti-friction bearings. It is only through the development of special types of bearings adapted to extreme service conditions that progress has been made in this field.

It is a foregone conclusion that the journal loads on mills used for rolling ferrous metals are severe and that high shock loads must be provided for. However, there is little basic information that serves to approximate bearing pressures in terms of the work for which the mill is intended and experimental determinations must usually be resorted to. A further consideration, in the use of anti-friction bearings, is the space limitation imposed by the design of the mill itself. The roll neck must be proportioned to withstand the heavy stresses to which it is subjected and this, in turn, determines the bore diameter of the bearing. On the other hand, the outside diameter of the roll determines the maximum outside diameter of the bearing.

*Engr., SKF Industries, Inc., New York.

Considerable experimental work has already been done abroad in the use of bearings for steel mill roll necks. This experience has served to indicate certain advantages to be obtained and has thrown considerable light on the practical problems that are involved in any such installation. One of the first installations was made at Hofors Bruk, Sweden, in 1921, at which time a carefully studied plan was formulated for considering the application. The problem was thoroughly reviewed from three angles: theoretical, mechanical and commercial.

Theoretical: Adopting proper methods and means of ascertaining journal loads under operating conditions. Mathematically derived values are not reliable on account of the many variables that must be properly considered. Maximum or peak loads are not necessarily a criterion for the determination of bearing capacity. The average working load is the principal consideration when anti-friction bearings are to be used. The theory that applies to plain bearings is not applicable to anti-friction bearings.

Mechanical: Necessity of proper designs that will facilitate mounting and dismounting of anti-friction bearings on roll necks and in the housings, effective enclosures to conform within space limitations, positive lubricating system, maintenance of close tolerances that are required when rolling form sections.

Commercial: The introduction of the use of anti-friction bearings must be done by selling the idea to the machine users rather than the manufacturer, i. e., a demand for its use must first be created in the field as a means of inducing the manufacturer to adopt it as standard. A demand can only be created on satisfactory demonstration of performance.

The sale of bearings directly to the user involves changing over existing mills. This, of course, presents difficulties that would not be encountered if the mills were designed originally to accommodate anti-friction bearing housings. As a result, it is reasonable to expect that changeovers will be more expensive than new installations.

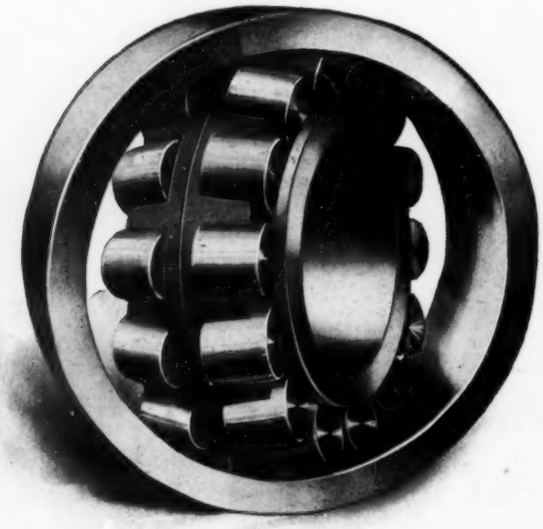

FIG. A—Spherical Journal Bearing.

These considerations have led to the use of the Spherical Journal Bearing which was primarily designed for heavy duty service, giving maximum load carrying capacity within limited dimensions. This type of bearing has been in successful use on railway car journals during the past five years and possesses features which are distinctly an advance of previous practice in the design and manufacture of anti-friction bearings.

The bearing is a self-contained, non-adjustable unit, consisting of an inner race, an outer race and two rows of barrel shape rolling elements. The outer race is ground spherical from the center of the bearing and provides true alignment for compensation of shaft deflection. At the same time it assures a static distribution of stress between the two rows of rollers. These two considerations are of very great importance in a heavy duty bearing since a concentration of stress, due to constraint, will lead to premature failure.

Rollers have a line contact with the inner race and a broad point contact with the outer race, an arrangement which facilitates the guiding of the rollers by means of their contact on the inboard end with the center flange of the inner race. Thrust loads are carried in either direction by virtue of the angular contact between rollers and races.

This bearing is well adapted to the peculiar requirements of steel mill service because of the following features:

I. Maximum radial load capacity is provided within a given space limitation.
II. Heavy intermittent thrust loads may be carried in either direction.
III. Unrestrained self-alignment, preventing the concentration of stress on one set of rollers.
IV. Absolute reliability in service, not subject to the operating limitations and maintenance problems of the plain bearing.
V. High degree of precision in operation, due to the close manufacturing tolerance characteristic of anti-friction bearings.

The Hofors Bruk Steel Works selected for their first problem a plain bearing, two high, 9″ wire mill. A device was developed by our Company of Sweden with which they were able to ascertain journal

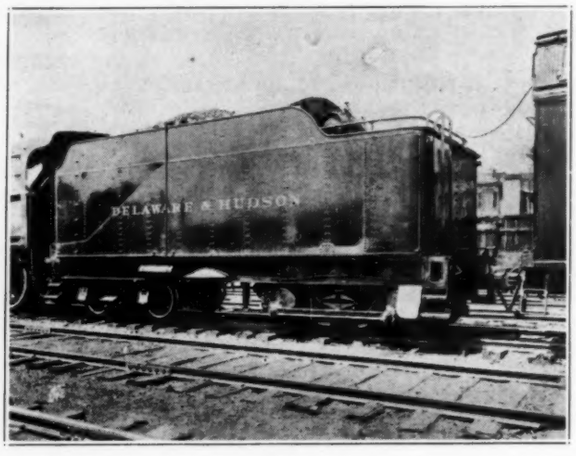

FIG. 1.

loads on the free and driven ends of the mill while it was in operation. This work was conducted without any modification of the side stand or interruption with the general operation of the mill.

Steel blanks with a carbon content of .80% were passed and a record was made of the amount of reduction of the metal per pass with respect to its thickness, power input, temperature of journals, period of time in seconds that the material was in the groove, approximate revolutions during each pass and the value of thrust loads. It was possible from data collected to analyze completely the process of rolling and also to make the necessary calculations for bearing dimensions to be used.

From data collected it developed that the effect of journal pressures that occur in the rolling of materials of like cross section and composition are dependent on the position of the grooves in the rolls. It was also ascertained that when an oval shaped section enters a square groove the resultant thrust load is about 8% to 15% of the radial load, whereas thrust load is negligible when a square section enters an oval groove.

The 9″ plain bearing wire mill was subsequently converted so that the rolls were equipped with our Spherical Journal Bearings. The same rolls were used and the necks of each were tapered to corre-

spond with the tapered bore of the bearing. This was resorted to as an easy method of mounting the bearing. The housings were designed in a way that enabled mounting the bearings on the rolls and in their sub-housings in the machine shop and then carried by crane to the point where the mill stand was located, and inserted into place as a unit. This not only simplified assembly of the bearings but also

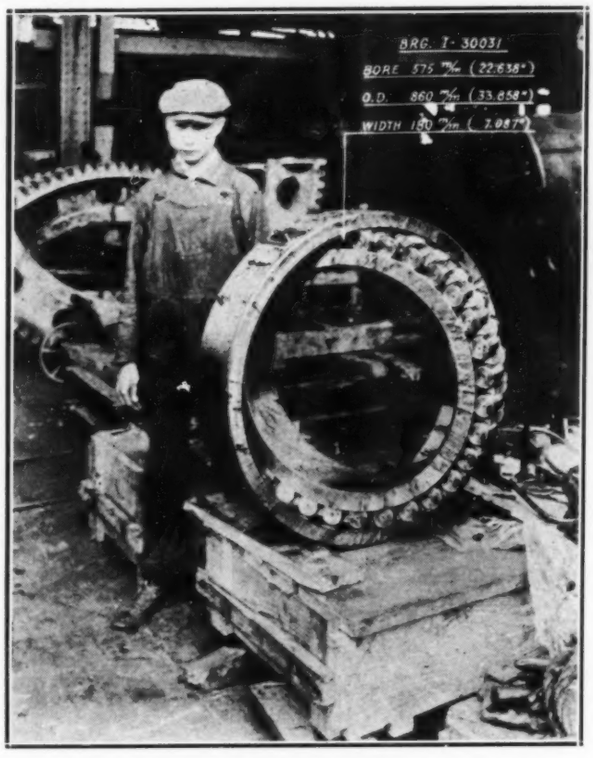

FIG. 2.

protected them against the entry of foreign matter into the housings, which might occur if the mounting was done in the mill proper.

As a means of stabilizing endwise and locating the rolls with respect to each other, an additional outboard bearing was mounted on one end of each roll. Labrynth enclosures provided protection against the entry of water into the housing. Foreign solid matter such as dirt, grit and steel scales were absolutely excluded. Grease was first used as a lubricant, later, as a result of considerable experimenting, a mixture of grease and drill oil was tested and proved to be very effective. This compound possessed the quality of forming an emulsion with water, therefore if any water did, by chance, enter the housing there was still enough lubricating property in the solution to lubricate the bearings and also protect them from rusting.

This mill has now been in operation for a considerable period of time and the service had from it is most satisfactory.

The experience gained, from the operation of the 9", two high mill at Hofors, was used by Witkowitz Iron Works, Czecho-Slovakia for development work on a 17" three high roughing mill. The determined journal pressure on this mill ranged from 30 to 40 tons per roll. It is used for reducing 3½" x 3½" bars to a ¾" square section, in nine passes. The design of housings involved certain features that were not encountered in the two high type mill. Nevertheless, by resorting to the use of bearings of special external dimensions the mill was finally placed into service.

Without entering into any further detail or describing the design, we quote from a report written by Witkowitz Iron Works which points out advantages that they have obtained from the use of anti-friction bearings, as compared with plain bearings, on the 17" roughing mill:

I. Power saving is better than 25%.

II. Close tolerance limits, to which dimensions of anti-friction bearings are manufactured, permit accurate adjustment of mill rolls. This is very important when rolling form sections, for it reduces the percentage of material rejected for being "off on dimensions."

III. Increase in production because of reduction in rejections, is reflected in lower overhead.

IV. The frequency of introducing lubricant into the housings and the amount of lubricant consumed are reduced, since the design provides for an oil tight housing chamber. This directly lowers maintenance charges.

V. Replacement of bearings is unnecessary, resulting in a further reduction on cost of "upkeep."

* * * *

Extensive experience had abroad pertaining to the application of anti-friction bearings on roll mills, though fundamental, must be interpreted to comply with American practice.

Our Company has, for some time, been conducting a survey of machinery used in the manufacture of steel. The investigation is not limited to any specific machine. It includes rolling mills of various kinds, mill tables, shears, hot or cold saws, gear reductions, cranes and other auxiliary equipment.

In this country it is general manufacturing practice to consider "production" a most important factor. This is evidenced in the design of our ma-

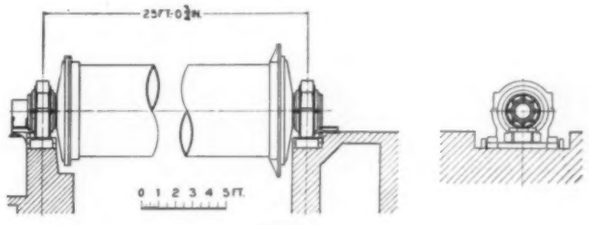

FIG. 3.

chines. They are larger and heavier than those used abroad. We operate them at a greater average rate of hours per day, per year, and expect them to last for a period of many years, although we subject them to service that might be considered as continuous.

If anti-friction bearings are to replace plain journals on steel mill roll necks, it is essential to know effective journal pressures, that is—variation in journal loads while the mill is in operation. This information is necessary so as to enable the selection of bearings of proper capacity, not only to provide for resultant loads that have to be carried, but also for the extent of service to which the machine would be subjected.

As it does not seem to be possible to ascertain variation in journal loads mathematically, the Engineering Department of our company have undertaken to develop some simple method for obtaining the required information on present plain bearing mills, without the necessity of altering or changing mill stands or interfering with the production of the machines. It is not unlikely that it will be possible to employ this same method for ascertaining journal pressure on other types of equipment, where loads are also mathematically indeterminate.

For several years our Spherical Journal Bearings have been used on installations where the conditions of service in some phase approximate those that prevail on machines used in the manufacture of steel. Their satisfactory performance warrants the description of a few typical cases.

Steam Railway Auxiliary Locomotive:

In the operation of locomotives for the hauling of freight, often it is necessary to increase the tonnage rating of the locomotive so as to maintain a

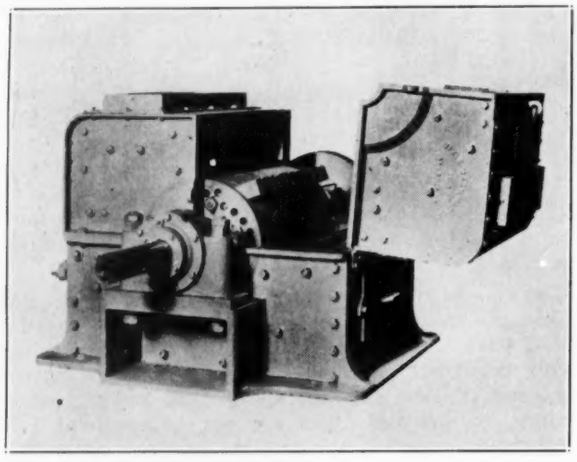

FIG. 4.

constant rate of speed on grades and level track. To accomplish this, the rear truck under the engine tender is substituted by an auxiliary locomotive.

Our Spherical Journal Bearings have been used in wheel journal boxes, of trucks, since 1922; the load per bearing has been calculated as 37,500 pounds, when operating at a speed of 15 miles per hour or 140 R.P.M.

Railway service imposes severe conditions of thrust and shock load, and necessitates continuous and exacting operation.

Cement Tube Mills:

In the manufacture of cement, very large tumblers or drums are used, the process is continuous and requires that material be introduced into the drum and discharged, while in operation; this is accomplished by using a hollow shaft, on which the bearings are mounted. It becomes necessary to use a shaft of large diameter and of sufficient cross section to support heavy loads that must be carried.

During 1924 our Spherical Bearings were installed on a drum 5½ feet in diameter and 26 feet long. The weight when loaded is 50 tons, imposing a load of 50,000 pounds per bearing.

Bearings used have an external dimension of 34 inches and the bores are 23 inches.

The installation is essentially one of continuous service.

Grinding Mills:

Shock loads resulting from unbalance on hammer type, grinding mills are most severe. This condition precludes the use of plain bearings on large mills.

A few years ago a manufacturer conducted a series of tests with several different types of bearings on 28″ x 42″ grinding mill, operating at 1500 R.P.M. The bearings were spaced 78″ center to center.

Self-aligning feature of our Spherical Roller Bearing provided required flexibility at the journals to compensate for deflection of shaft, caused by unbalance of rotating parts.

This made the problem feasible and our Spherical Journal Bearings are now used as standard.

Safe Practices in Connection With the Operation of High Tension Power

Central Station Practices
Coal Mining Practices
Iron and Steel Plant Practices

To Be Presented

MONDAY, JUNE 13th, 1927

At The

ANNUAL CONVENTION AND IRON AND STEEL EXPOSITION

Pittsburgh, Penna.

Central Station, Mining, and Iron and Steel Plant Electrical Engineers are invited to forward any or all of their rules in connection with the safe practices of high tension power in their respective plants.

Send all literature to:

C. L. Baker, Chairman,
Safety Engineering Division,
A. I. & S. E. E.,
705 Empire Building,
Pittsburgh, Penna.

MEETINGS AND PAPERS

PITTSBURGH SECTION

R. F. Chaffin, Chairman J. F. Kelly, Secretary

Saturday, March 19th, 1927

Blue Room, Wm. Penn Hotel,

Dinner 6:30 P. M. Technical Session 8:00 P. M.

Subject:

"Power Factor Correction," by W. H. Feldmann, Engineer, Electric Machinery Manufacturing Company, Minneapolis, Minn.

PHILADELPHIA SECTION

Saturday, March 5th, 1927

"A Symposium, the Parallel Operation of Motor Generator Sets, Rotary Converters and Rectifiers." To be handled by D. M. Petty, Elec. Supt., Bethlehem Steel Company, Bethlehem, Pa.

All meetings, unless otherwise noted, will be held at the Engineers' Club, 1317 Spruce Street, and will start promptly at 7:30 P. M. Dinner at 6:00 P. M.

CHICAGO SECTION

Wednesday, March 2nd, 1927

"Present Tendencies in the Application of Graphic Instruments," by Mr. J. W. Esterline, Pres., Esterline-Angus Co., Indianapolis, Ind.

BIRMINGHAM SECTION

Saturday, February 26th, 1927

"The Design of Direct Current Motors," by A. M. MacCutcheon, Chief Engr., Reliance Electric & Engineering Co., Cleveland, Ohio.

Saturday, March 26th, 1927

"Automatic Control," by F. R. Fishback, President, Electric Controller & Mfg. Company, Cleveland, Ohio.

Chairmen and Secretaries

Section	Chairman	Secretary
Philadelphia	F. O. Schnure	Linn O. Morrow
Cleveland	A. L. Reichert	A. R. Lintern
Chicago	Elbert Lewis	Gordon Fox
Pittsburgh	R. F. Chaffin	John F. Kelly
Birmingham	W. W. Garrett	J. E. Sayer

Items of Interest

"Roosevelt Avenue Bridge," New York the largest trunnion bascule lift bridge east of Chicago, and probably the largest of its exact type in the world, will soon carry Manhattan subway trains across Flushing River to Flushing, Long Island.

The bridge consists of two movable leaves which turn upon huge trunnions and open like the blades of a jacknife to permit the passage of ships. Each leaf is 152 feet long and weighs close to four million pounds. So delicately is this great weight counterbalanced, however, that four 80-horsepower electric motors can open or close the bridge in 45 seconds against the pressure of a 25-mile-an-hour wind. Three hundred and twenty-eight horsepower of Westinghouse motors provide the motive power. The clear heighth of the bridge is 25.6 feet above mean high water, which is sufficient to permit the passage of ordinary tug-boat traffic without opening the bridge.

An unusual feature of this bridge is that it is double-decked. The upper level will carry three rapid-transit railroad tracks, and the lower will provide a very much needed vehicular thoroughfare for this locality.

Electric Safety System

Special attention has been given to insuring complete safety in the operation of this bridge, and the engineers of the Department of Plant and Structures of the City of New York, assisted by the engineers of the Westinghouse Company, have devised a system that is regarded as completely adequate.

When a ship, which is unable to go under the bridge, wishes to pass up the river, it signals the bridge operator. The operator is unable to move the bridge, however, for all motive power circuits on the bridge are normally dead. His first step is to signal to the towerman controlling the operation of the trains that he wishes to open the bridge.

The towerman then sets the signals against the trains (which, however, he cannot do until the bridge and its approaches are clear of trains), and this operation automatically energizes the bridge's motive power circuits.

The bridge operator is now able to start successively the various motors which perform the following functions:

1. To withdraw two huge steel bolts, weighing 400 pounds each, which lock the two leaves of the bridge together while in closed position.

2. After the bolts are fully withdrawn the tail lock struts which brace the bridge leaves at their shore ends are withdrawn.

3. The bridge leaves are lifted and open the way for the vessel.

After the passage of the vessel, the bridge operator closes the bridge and locks it, and not until everything is in perfect order, can the towerman set "clear" signals for the trains.

This system is so arranged that each step in the process of opening or closing the bridge must be taken in exactly the right order, and no step can be taken until the previous one has been properly completed. A signal light on the operator's desk at the controllers indicates the proper performance of each step. Should anything jam or should power fail, everything becomes locked in position so that no part of the mechanism can "run wild." The leaves do not open or close completely in a single movement, but stop just before they reach the end of their travel, the last few inches being taken at a very low speed. This prevents damaging the bridge structure by slamming it against the stops. Duplicate motive power equipment is provided to insure continuous operation should any piece of apparatus go out of commission for any reason.

The total cost of the bridge and its approaches is $2,700,000. The bridge is being constructed under supervision of the Department of Plant and Structures, Albert Goldman, Commissioner, Edward A. Byrne, Chief Engineer. The Arthur McMullen Company is the general contractor, and the McClintic-Marshall Company have fabricated and erected the steel superstructure.

The largest steel plant in the west, that of the Colorado Fuel & Iron Company at Pueblo, Colorado, has now started operation with its new electrical equipment. This company recently made a complete (with the exception of its blooming mills) change-over from steam to electric drive, using electricity generated on the premises in the largest industrial power plant in the Rocky Mountain region.

The company was incorporated in 1892 and, until a few years ago, all power used in the plant was derived from steam engines. Electrification was first considered during the period following the war, and the initial program included a power plant, the electrification of the rod and 10-inch mill, the 14-inch mill and the rail mill.

All the main electrical equipment, including the turbine generators in the power house, was furnished by the General Electric Company. Among the items are three 10,000-kilowatt turbine generators to furnish power for the various mills, and two 1000-kilowatt motor generators to furnish direct current to the power house and the adjacent mills.

An outstanding feature of the fuel supply is blast furnace gas cleaned by electric precipitators. Powdered coal is used as a standby fuel. The reduced steam requirements resulting from electrification, together with the more efficient use of blast furnace gas, has resulted in shutting down approximately 85% of a boiler plant containing thirty 500-horsepower, hand-fired boilers.

The switch house contains three buses, one main 6600-volt bus for supplying large blocks of power to the various mills, an auxiliary 6600-volt bus for supplying smaller blocks of power to various outlying operations, and a 2300-volt auxiliary bus for the power house auxiliaries. All power leaves the power house at 6600 volts, as generated and as used by all the large a-c. motors.

The rod and 10-inch mills, the first in operation, are located in the same building and use the same billet heating furnaces and continuous mill. This mill was originally driven by four reciprocating engines, now replaced by two 3,000-horsepower, slip-ring, induction motors; two 1,000-horsepower motors

of the same type; two 1500-horsepower, d-c., adjustable speed motors, and a 300-horsepower motor of the same type. One of the 1500-horsepower motors, located in a separate motor room, is supplied by a 1600-kilowatt synchronous converter also located in the same room. The other 1500-horsepower and the 300-horsepower motor, located in the main engine room, are supplied by another synchronous converter of 1600 kilowatts capacity. All the a-c. motors drive the stands through reduction gears, whereas the d-c. motors are direct connected.

The 14-inch Merchant mill was originally driven by a single engine connected to the continuous stands with rope drives connecting the intermediate and finishing stands. This was replaced by a 1500-horsepower, d-c , adjustable speed motor connected directly to the intermediate stands with a rope drive to the continuous stands, and a similar 750-horsepower motor directly connected to the finishing stands. A 1600-kilowatt synchronous converter, a duplicate of the two in the rod and 10-inch mills, supplies power to these two motors.

The rail mill was formerly driven by an engine on the roughing stand and a second engine on the intermediate and finishing stands. These two engines were replaced by a 2,000-horsepower, a-c., slip-ring, induction motor on the roughing stand and a similar 3,000-horsepower motor on the intermediate stands. The finishing stand was separated from the intermedite, and a 1200-horsepower, a-c., slip-ring motor now drives this stand. All these motors drive the mills through reduction gears, and in the case of the roughing and intermediate stands, the original engine fly wheels were mounted on new bearings and connected to the mill side of the reduction gears. Permanent resistance is inserted in the secondary of these motors to take advantage of the flywheel effect.

Large economies are expected in power, labor and maintenance by the electrification. The old engines which exhausted to atmosphere were uneconomical and their operation required a larger number of men than is required for the motors.

Safety rules for installing and using electrical equipment in coal mines, sponsored by the Bureau of Mines, Department of Commerce, and the American Mining Congress, have just been made public by the Bureau of Mines.

In preparing the rules five basic measures for safeguarding the use of electricity in mines have been followed, viz:

Removing the contributory causes of accidents or danger.

Removing from the vicinity of electrical apparatus all elements susceptible to the influence of electricity.

Keeping the electric current where it belongs, if possible; if not, limiting the area of its activity by protective devices.

Using a large factor of safety in the selection, installation, and inspection of equipment.

Having full control of the operation of electrically driven machines.

The new safety rules have been published in Technical Paper 402, copies of which may be obtained from the Bureau of Mines, Department of Commerce, Washington, D. C.

The largest turbine generator ever used by a steel mill will be installed by the Illinois Steel Company at its Gary (Indiana) plant. This equipment, which will be furnished by the General Electric Company, will produce 30,000 kilowatts at 25 cycles, 6600 volts, and will operate condensing.

The tendency of steel mills to use large prime movers is indicated, not only by this, but also by other similar installations to be made by other plants. The Tennessee Coal, Iron & Railroad Company is soon to install two 20,000-kilowatt turbine generators, and another unit of the same size will be installed by the Bethlehem Steel Company at Sparrow's Point, Md.

The Duquesne Light Company of Pittsburgh, Pa., has placed with the Westinghouse Electric and Manufacturing Company an order for fifty automatic network units. This decision of the Duquesne Light Company to adopt a low-voltage alternating current distribution system for the Pittsburgh business district is an indication of the rapid development of power distribution there.

Automatic switching is accomplished by means of these units which will be of the submersible type, sealed for use in moist underground chambers. The initial deliver of fifteen units was made during the first week of January. The conversion of Duquesne Light Company's 40,000 kw. downtown load to this system will take several months.

The low-voltage alternating current network system has also been adopted in New York City, Memphis, Dallas, New Orleans, Miami, Atlanta and other cities.

The Farrel Foundry & Machine Company announce that they have made important improvements in the design of their gear generators, which they are offering to producers of gears in quantities. These machines have been described from time to time in our journal, and most of our readers will, therefore, be familiar with the general principles of the machines and the gears which they produce.

The Farrel Foundry & Machine Company have taken extreme care while designing these machines to embody the most modern machine tool features in the hope that they will be up to date for a number of years, and for a long period produce more accurate gears more rapidly than other gear machines.

The Farrel Foundry & Machine Company have the advantages that while developing gear generators they have produced and are constantly producing a large volume of gears of all sizes, and are therefore familiar with every kind of production difficulty which arises, and can make improvements in the mechanism of the machines that their experience indicates are necessary. The benefit of this experience, and also other valuable technical data for operating the machine and designing the gears is given to each purchaser of a gear machine.

They furnish, besides, a complete range of arbors, face plates, driving dogs, and cutter tail brackets, centers for shafts, chucks, etc., gear tooth comparator together with gauge blocks of extreme accuracy, graduated squares for gauging the apex of the teeth, and an extraordinary number of change gears. In addition straight guides for the cutters

are supplied so that they can be exchanged for the helical guides when it is required to product straight tooth gears.

The machine is exceptionally adaptable. It will cut straight tooth gears, helical gears, staggered tooth double helical gears, and continuous tooth Sykes gears.

The Farrell Foundry & Machine Company also announce a new gear book, which contains illustrations showing nearly every kind of gear drive which they manufacture, and a complete series of dimension sheets and horsepower capacity sheets for each of their standard sizes. In addition there is valuable technical data on the calculation of gears. A postcard requesting this catalog will bring it by return mail.

A new type power panel has been announced by the Square D Company, Detroit, Michigan.

In addition to the convertible feature which permits a quick and easy change to 30, 60 or 100 ampere fuses in the circuits, testing facilities have been added and a duplex design cabinet makes it possible to reduce the size of the power panel cabinet materially.

Test jacks are provided in each circuit. These test jacks are mounted on individual insulating bases and holes are provided in the cabinet door so that the test plug can be inserted to the jack without opening the door. When the plug is not inserted, the opening in the door is kept closed by means of a sliding cover.

The cabinet is of the duplex design, for column mounting with doors on each side of the cabinet. The main bus bars are brought down the side of the cabinet and in this way it is possible to place half the total number of circuits on each side of the cabinet. This construction reduces the size of the cabinet considerably as compared to the panel where all the circuits must be placed on the one side.

A compartment at the top or bottom encloses the main lugs which are set at an angle making it easy for the connections to be made.

All cabinet trims are hinged so that it is a one man job to get access to any of the gutters.

All fuse clips and jaws are mounted on individual insulating bases and it is but a matter of minutes to remove and replace a burned fuse jaw from the front of the panel.

To convert the circuits from 30 to 60 to 100 ampere fuse spacings all that is necessary is to loosen a few nuts holding the supporting grids and the individual bases can be moved to the correct spasing as indicated on the grids. It takes but a few minutes' time.

Research on the utilization of manganiferous iron ores has been undertaken by the North Central experiment Station of the Bureau of Mines, Department of Commerce, located at Minneapolis, Minn., in co-operation with the University of Minnesota School of Mines experiment station. The investigation may be divided as follows:

1. The use of manganiferous iron ores with respect to effect on blast-furnace operation; effect of high-manganese pig iron on the quality of steel; decrease in ferromanganese by the use of high-manganese pig iron; and desulphurization of steel through the presence of manganese.

2. The utilization of manganiferous iron ores in the production of ferromanganese.

3. The use of 6 to 10 per cent manganese alloys as additions to steels containing more than 0.3 per cent carbon.

Manganese may be considered indispensable in all present steel-making processes. It is not only a superior deoxidizer but it adds desirable physical properties to the finished steel. Users of manganese fully appreciate the situation in regard to domestic reserves and realize that the United States is dependent upon imports of high-grade manganese ore and ferromanganese. Information compiled by the Mining and Metallurgical Society of America indicates that the reserves of ore, containing 35 per cent manganese, would supply the domestic demand for about three years at the present rate of steel making. This situation suggests careful consideration of low-grade ores with a view to conserving a limited and vital resource.

Manganiferous iron ores, differing in composition, occur in several districts in the United States. The Cuyuna district of central Minnesota, however, contains the most extensive deposits as yet discovered; they have also the advantage of proximity to the Great Lakes. These ores are now finding an increasing market as sulphur scavengers in the blast furnace and for producing high-manganese pig iron. It has been claimed that a superior quality of steel can be made from high manganese pig. There is evidence that additions of ferromanganese are less when high-manganese pig is used.

Cuyuna ores may be divided into two classes—the so-called high-phosphorus, low-silica, or brown ores; and the high-silica, low-phosphorus, or black ores. It has been estimated that the manganese in the reserves of the black ores is only one-eighth of that in the reserves of brown ores. Increasing amounts of the brown ores have been shipped the last few years and have been mixed with other ores to regulate the manganese content of the pig iron made in the blast furnace. The use of these ores may therefore be taken as an index of the popularity of high-manganese pig iron. The brown ores are high in moisture and many of them have an alumina content that is high in comparison with the silica.

The bahavior of a blast-furnace burden composed of 100 per cent Cuyuna brown ore has never been determined on a commercial scale. The black or high-silica ores were used commercially during the World War, and considerable data are available regarding the results obtained. It seemed desirable to make some blast-furnace tests of the brown ores to determine the slag composition that gives the best recovery of manganese and to ascertain whether the ores would offer any difficulty in smelting. It was also important to know the fuel requirements and the grade of alloy which could be made from these ores. In addition, blast-furnace tests were needed to furnish a quantity of metal for use in developing methods for separating the iron and manganese in low-grade spiegel or manganiferous pig iron. As tests with a small commercial furnace were too expensive to warrant serious consideration, the development of an experimental blast furnace for making

the tests was undertaken by the Bureau of Mines. This development required several years and called for the exercise of much patience by all persons concerned. An experimental furnace, in addition to being a necessary adjunct to the manganese problem, also had great promise as an instrument for fundamental blast-furnace research.

After 35 tests with 16 furnaces, ranging in height from a few feet to 20 feet, had been made, a satisfactory furnace was designed by the Bureau of Mines and erected by the University of Minnesota.

As a result of numerous tests conducted with this experimental furnace, there has been obtained fundamental data on the blast furnace and information regarding the smelting of the brown Cuyuna ores. The runs in the experimental furnace have also yielded 134 tons of metal which are now available for a study of the problem of separating the iron, manganese, and phosphorous If their separation can be made, the production of a higher-grade manganese alloy low in phosphorus will be possible. The manganese content of the metal on hand ranges from 2 to 15 per cent; the phosphorus is uniformly high, about 0.6 per cent. Sulphur is present in negligible quantities.

At several plants in this country low-grade spiegeleisen is used to recarburize and deoxidize rail heats. This practice would furnish a market for Cuyuna ores were not their phosphorus content so high. Low-carbon steel can not be made by this method, but a considerable tonnage of steel containing 0.3 per cent and more carbon is produced annually. If the trouble due to the phosphorus can be overcome by mixing brown ores with black low-phosphorus ores, or if phosphorus can be eliminated in a basic electric furnace, the use of manganiferous ores can be increased.

At present not enough data are available for determining the most efficient way of utilizing these ores. More information on their present use in the blast furnace is needed. The recovery of manganese in the pig iron and the extent of improved desulphurization should be determined. Although the practice of using high manganese pigs to obtain residual manganese seems to be increasing, there are still differences of opinion as to what benefits are realized. The information needed must be sought through the co-operation of steel companies and blast-furnace operators, inasmuch as they alone can furnish comparative data. The development of new methods for utilizing the Cuyuna ores must depend on experiments. The first step in the process, the production of low-grade spiegel in the blast furnace from 100 per cent Cuyuna ores, has been completed. Small-scale converter and open-hearth tests are not in progress. Some phases of the problem can be studied on a laboratory scale. It was for the purpose of determining more accurately the technologic problems and the economic conditions that affect the use of these ores that this investigation has been undertaken.

The Harnischfeger Corporation, Milwaukee, Wis., successor to Pawling & Harnischfeger Company, announces the removal of its Branch Office at Jacksonville, Fla., from the Peninsular Casualty Bldg., to 509 East Eighth Street, Mr. F. W. Truex is branch manager in charge.

After March 1, the Jacksonville Branch Warehouse will also be moved from its present location, 1465 Kings Road to 509 East Eighth Street. This combining of office and warehouse will make possible the affording of even still better service to users of P&H equipment.

Beginning February 1, the Trumbull-Vanderpoel Electric Manufacturing Company, manufacturers of safety and knife switches, will have quarters at No. 51 Barclay Stseet. This office will be under the supervision of George J. Gillingham and Fred Carry, who have been identified with the sales force of this company for some time.

A Chicago Branch Office and distributing point will be opened in the Madison Terminal Bldg., and H. T. Doolittle, who has represented this company in this territory as the D-E Distributing Co., will be in charge.

The Company feels that with their own offices established in the two largest cities of the country, with complete stocks, better and closer co-operation can be had with the distributing forces for T-V Safety Switches.

Two contracts covering 4—33,333 kv-a transformers and 7—25,000 kv-a transformers respectively, for the Southern California Edison Company have been placed with the Westinghouse Electric and Manufacturing Company. These units will be manufactured at the Sharon Works for delivery during the coming spring and summer. The 33,333 kv-a units are the largest single phase transformers to be built from the standpoint of kv-a, surpassing the 31,400 kv-a units also manufactured by the Westinghouse Company. All of these units are to be single phase, self cooled—air blast, and for use on the 220,000 volt system of the Southern California Edison Company, one of the oldest operating companies in the 220,000 volt field.

The transformers are equipped with cooling radiators enabling them to carry 60% of the maximum capacity. Each unit will also be equipped with its own individual blower and motor controlled by oil temperature to increase the efficiency of the radiators. The transformers are to be built with the shell form of construction and will be equipped with inertaire apparatus for protection of the transformers and preservation of the oil.

The 33,333 kv-a larger trainsformers go to the new Sunset Steam Plant of the Southern California Edison Company for which Stone & Webster, Inc., of Boston, have acted as consulting engineers. They will transform the generator voltage of 16,000 volts to the 220,000 volt system voltage and will be more than 99% efficient at all practical operating loads.

These transformers are large in physical dimensions, each transformer, completely set up, weighing more than one hundred tons. From the top of the high voltage bushing to the ground the transformers will measure 400 inches but by specially sectionalizing tank the shipping height will be cut down sufficiently to ship the transformers in their own tank under their own oil. This protects the transformers from moisture absorption during shipment.

The 7—25,000 kv-a transformers go to the Lighthipe Substation and will be used to connect 220,000

volt and 60,000 volt transmission systems. They are similar in construction to the four larger units.

The first and only large installation of equipment for the electric precipitation of ash in a powdered fuel boiler plant is being installed at the Trenton Channel power plant of the Detroit Edison Company. The installation, having what will probably be the highest power rating of any single electric precipitation of plant ever built, is being made under the supervision of the Research Corporation of New York City, and involves the use of the Cottrell process.

The smoke given off from the Trenton Channel powdered fuel boiler plant carries with it a large amount of fine ash which, if it were not removed in some way, would result in the distribution from the stacks of many tons of ash over the surrounding countryside. By means of the new precipitator this will be practically eliminated.

Nine precipitator units will comprise the final installation, each being served by two 25 kv-a. electrical sets. Two precipitator units are already in use and the remainder will be installed early this year.

The high voltage power will be supplied from 18 specially designed 25-kv-a. transformers, of which 14 units are now under construction at the Pittsfield plant of the General Electric Company. These units will step up the 220-volt, single-phase, 60-cycle power supply to 75,000 volts. The high voltage will then be passed through mechanical rectifiers built by the Research Corporation and each driven by a single-horsepower, ball-bearing, synchronous motor of special design and furnished by the General Electric Company. The high voltage direct current from the rectifier will be applied directly to the treaters.

The precipitators are of the graded resistance type, consisting of parallel grounded concrete plates between which will be suspended anodes connected to the negative side of the direct-current circuit. The positive side of the direct-current circuit will be connected to the concrete plates and a corona discharge will flow from the suspended anodes to the concrete cathodes.

The smoke exhausted from the boiler plant will pass between the concrete plates and the suspended ash will be ionized by the corona discharge and deposited on the concrete plates whence it will be removed periodically by mechanically means, dropping into hoppers below. Periodic removal from the hoppers will complete the process.

By means of a number of taps in the low-voltage winding of each transformer, it will be possible to select the best operating voltage at which the precipitators will operate. These taps will provide, besides the 75,000 volts, voltages of 70,000, 65,000 and 55,000.

A new type of induction motor which, with its control, is even simpler to operate than the ordinary squirrel cage motor and compensator, is announced by the General Electric Company. A complete line of these motors, bearing the type designation FT and ranging in ratings from 7½ to 50 horsepower, has been placed on the market.

The new motor marks the culmination of several years of investigation, development and research in the endeavor to meet the demand for a motor embodying simplicity, reliability, low cost and line switch control involving full voltage starting. While large numbers of high reactance motors of somewhat similar characteristics have been built and applied during the period of development, this is the first co-ordination of a complete line for general purpose application.

The FT motor is in general suitable for application wherever the ordinary squirrel cage induction motor with a compensator has been used. It is designed to start on full voltage giving slightly higher starting torque but approximately the same starting current as the ordinary squirrel cage induction motor started with the compensator connected to the 80% tap.

In appearance the new motors are the same as the ordinary squirrel cage induction motor. Rotors are of the cast aluminum type with bars so shaped and located in the punchings as to give a high reactance effect at starting. Starting current is within the N.E.L.A. limitations up to and including the 30-horsepower size.

Control apparatus required is very simple. An ordinary line switch of proper capacity can be used, but, in order to obtain proper overload and undervoltage protection, the motors are recommended for use with magnetic starting switches using push button control. Where necessary, on the larger sizes, a compensator or resistor starter may be used as in the case of the ordinary squirrel cage induction motor.

The advantages are low cost, simplicity, reliability, low starting current permitting the use of a line switch, elimination of the possibility of abuse by inexperienced operators, and ready adaptation to automatic control by pressure governor, flat switch, etc.

International Combustion Engineering Corporation officially announced the acquisition of the capital stock of the Heine Boiler Company, one of the oldest and leading water-tube boiler manufacturers in the United States. This acquisition gives the International Combustion Engineering Corporation large boiler shop facilities at St. Louis, Missouri, and Phoenixville, Pennsylvania.

All types of water tube boilers will be manufactured at St. Louis, including the new Sinuous Header type recently placed on the market. The manufacture of the Ladd water-tube boilers and the new Combustion steam generators will also be centered in the St. Louis plant.

The acquisition of the Heine Company will enable the International Combustion Engineering Corporation to furnish to its customers complete steam generating units fired with pulverized fuel or mechanical stokers, all of its own manufacture.

It is understood this new acquisition requires no financing by International Combustion Engineering Corporation, the Heine Company having been acquired through a cash payment. Mr. C. R. D. Meier will remain as President of the Heine Boiler Company.